SCIENCE

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*ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.**

THE first thought in the minds of all of us to-night is that since we met last year the great Queen, in whose reign nearly all the meetings of the British Association have been held, has passed to her rest.

To sovereigns most honors and dignities come as of right; but for some of them is reserved the supreme honor of an old age softened by the love and benedictions of millions; of a path to the grave, not only magnificent, but watered by the tears both of their nearest and dearest, and of those who, at the most, have only seen them from afar.

This honor Queen Victoria won. All the world knows by what great abilities, by what patient labor, by what infinite tact and kindliness, the late Queen gained both the respect of the rulers of nations and the affection of her own subjects.

Her reign, glorious in many respects, was remarkable, outside these islands, for the growth of the Empire; within and without them, for the drawing nearer of the Crown and the people in mutual trust; while, during her lifetime, the developments of science and of scientific industry have altered the habits and the thoughts of the whole civilized world.

The representatives of science have already expressed in more formal ways their sorrow at the death of Queen Victoria, and the loyalty and confident hope for the future with which they welcome the accession of King Edward. But none the less, I feel

* Glasgow meeting, 1901.

sure that at this, the first meeting of the British Association held in his reign, I am only expressing the universal opinion of all our members when I say that no group of the King's subjects trusts more implicitly than we do in the ability, skill and judgment which His Majesty has already shown in the exercise of the powers and duties of his august office; that none sympathize more deeply with the sorrows which two great nations have shared with their sovereigns; and that none cry with more fervor, 'Long live the King!'

But this meeting of the British Association is not only remarkable as being the first in a new reign. It is also the first in the new century. It is held in Glasgow at a time when your International Exhibition has in a special sense attracted the attention of the world to your city, and when the recent celebration of the ninth jubilee of your University has shown how deeply the prosperity of the present is rooted in the past. What wonder, then, if I take the chair to which you have called me with some misgivings? Born and bred in the south, I am to preside over a meeting held in the largest city of Scotland. As your chosen mouthpiece I am to speak to you of science when we stand at the parting of the centuries, and when the achievements of the past and present, and the promise of the future, demand an interpreter with gifts of knowledge and divination to which I cannot pretend. Lastly, I am president of the British Association as a disciple in the home of the master, as a physicist in a city which a physicist has made forever famous. Whatever the future may have in store for Glasgow, whether your enterprise is still to add wharf to wharf, factory to factory and street to street, or whether some unforeseen 'tide in the affairs of men' is to sweep energy and success elsewhere, fifty-three years in the history of your city will never be forgotten while civilization lasts.

More than half a century ago, a mere lad was the first to compel the British Association to listen to the teaching Joule, and to accept the law of the conservation of energy. Now, alike in the most difficult mathematics and in the conception of the most ingenious apparatus, in the daring of his speculations and in the soundness of his engineering, William Thomson, Lord Kelvin, is regarded as a leader by the science and industry of the whole world.

It is the less necessary to dwell at length upon all that he has done, for Lord Kelvin has not been without honor in his own country. Many of us, who meet here to-night, met last in Glasgow when the University and city had invited representatives of all nations to celebrate the jubilee of his professorship. For those two or three days learning was surrounded with a pomp seldom to be seen outside a palace. The strange middle-age costumes of all the chief universities of the world were jostling here, the outward signs that those who were themselves distinguished in the study of Nature had gathered to do honor to one of the most distinguished of them all.

Lord Kelvin's achievements were then described in addresses in every tongue, and therefore I will only remind you that we, assembled here to-night, owe him a heavy debt of gratitude; for the fact that the British Association enters on the twentieth century conscious of a work to do and of the vigor to do it is largely due to his constant presence at its meetings and to the support he has so ungrudgingly given. We have learned to know not only the work of our great leader, but the man himself; and I count myself happy because in his life-long home, under the walls of the university he served so well, and at a meeting of the Association which his genius has so often illuminated, I am allowed, as your President, to assure him in your name of the

admiration, respect, nay, of the affection, in which we all hold him.

I have already mentioned a number of circumstances which make our meeting this year noteworthy; to these I must add that for the first time we have a Section for Education, and the importance of this new departure, due largely to the energy of Professor Armstrong, is emphasized by the fact that the Chair of that Section will be occupied by the Vice-President of the Committee of Council on Education—Sir John Gorst. I will not attempt to forecast the proceedings of the new Section. Education is passing through a transitional stage. The recent debates in Parliament; the great gifts of Mr. Carnegie; the discussion as to university organization in the north of England; the reconstitution of the University of London; the increasing importance attached to the application of knowledge both to the investigation of nature and to the purposes of industry, are all evidence of the growing conviction that without advance in education we cannot retain our position among the nations of the world. If the British Association can provide a platform on which these matters may be discussed in a scientific but practical spirit, free from the misrepresentations of the hustings and the exaggerations of the partisan, it will contribute in no slight measure to the national welfare.

But amid the old and new activities of our meeting the undertone of sadness, which is never absent from such gatherings, will be painfully apparent to many of us at Glasgow. The life-work of Professor Tait has ended amid the gloom of the war-cloud. A bullet, fired thousands of miles away, struck him to the heart, so that in their deaths the father and the brave son, whom he loved so well, were not long divided. Within the last year, too, America has lost Rowland; Viriamu Jones, who did yeoman's service for education and for science, has succumbed to a long and painful illness; and one who last year at Bradford seconded the proposal that I should be your president at Glasgow, and who would unquestionably have occupied this chair before long had he been spared to do so, has unexpectedly been called away. A few months ago we had no reason to doubt that George Francis FitzGerald had many years of health and work before him. He had gained in a remarkable way not only the admiration of the scientific world, but the affection of his friends, and we shall miss sadly one whom we all cared for, and who, we hoped, might yet add largely to the achievements which had made him famous.

THE SCIENCE OF THE NINETEENTH CENTURY.

Turning from these sad thoughts to the retrospect of the century which has so lately ended, I have found it to be impossible to free myself from the influence of the moment and to avoid, even if it were desirable to avoid, the inclination to look backward from the standpoint of to-day.

Two years ago Sir Michael Foster dealt with the work of the century as a whole. Last year Sir William Turner discussed in greater detail the growth of a single branch of science. A third and humbler task remains, *viz.*, to fix our attention on some of the hypotheses and assumptions on which the fabric of modern theoretical science has been built, and to inquire whether the foundations have been so 'well and truly' laid that they may be trusted to sustain the mighty superstructure which is being raised upon them.

The moment is opportune. The three chief conceptions which for many years have dominated physical as distinct from biological science have been the theories of the existence of atoms, of the mechanical nature of heat, and of the existence of the ether.

Dalton's atomic theory was first given to the world by a Glasgow professor—Thomas Thomson—in the year 1807, Dalton having communicated it to him in 1804. Rumford's and Davy's experiments on the nature of heat were published in 1798 and 1799 respectively; and the celebrated Bakerian Lecture, in which Thomas Young established the undulatory theory by explaining the interference of light, appeared in the *Philosophical Transactions* in 1801. The keynotes of the physical science of the nineteenth century were thus struck, as the century began, by four of our fellow-countrymen, one of whom—Sir Benjamin Thompson, Count Rumford—preferred exile from the land of his birth to the loss of his birthright as a British citizen.

DOUBTS AS TO SCIENTIFIC THEORIES.

It is well known that of late doubts have arisen as to whether the atomic theory, with which the mechanical theory of heat is closely bound up, and the theory of the existence of an ether have not served their purpose, and whether the time has not come to reconsider them.

The facts that Professor Poincaré, addressing a congress of physicists in Paris, and Professor Poynting, addressing the Physical Section of the Association, have recently discussed the true meaning of our scientific methods of interpretation; that Dr. James Ward has lately delivered an attack of great power on many positions which eminent scientific men have occupied; and that the approaching end of the nineteenth century led Professor Hæckel to define in a more popular manner his own very definite views as to the solution of the 'Riddle of the Universe,' are perhaps a sufficient justification of an attempt to lay before you the difficulties which surround some of these questions.

To keep the discussion within reasonable limits I shall illustrate the principles under review by means of the atomic theory, with comparatively little reference to the ether, and we may also at first confine our attention to inanimate objects.

THE CONSTRUCTION OF A MODEL OF NATURE.

A natural philosopher, to use the old phrase, even if only possessed of a most superficial knowledge, would attempt to bring some order into the results of his observation of nature by grouping together statements with regard to phenomena which are obviously related. The aim of modern science goes far beyond this. It not only shows that many phenomena are related which at first sight have little or nothing in common, but, in so doing, also attempts to explain the relationship.

Without spending time on a discussion of the meaning of the word 'explanation,' it is sufficient to say that our efforts to establish relationships between phenomena often take the form of attempting to prove that, if a limited number of assumptions are granted as to the constitution of matter, or as to the existence of quasi material entities, such as caloric, electricity and the ether, a wide range of observed facts falls into order as a necessary consequence of the assumptions. The question at issue is whether the hypotheses which are at the base of the scientific theories now most generally accepted are to be regarded as accurate descriptions of the constitution of the universe around us, or merely as convenient fictions.

Convenient fictions be it observed, for even if they are fictions they are not useless. From the practical point of view it is a matter of secondary importance whether our theories and assumptions are correct, if only they guide us to results which are in accord with facts. The whole fabric of scientific theory may be regarded merely as a gigantic 'aid to memory'; as a means for producing apparent order out of dis-

order by codifying the observed facts and laws in accordance with an artificial system, and thus arranging our knowledge under a comparatively small number of heads. The simplification introduced by a scheme which, however imperfect it may be, enables us to argue from a few first principles, makes theories of practical use. By means of them we can foresee the results of combinations of causes which would otherwise elude us. We can predict future events, and can even attempt to argue back from the present to the unknown past.

But it is possible that these advantages might be attained by means of axioms, assumptions and theories based on very false ideas. A person who thought that a river was really a streak of blue paint might learn as much about its direction from a map as one who knew it as it is. It is thus conceivable that we might be able, not indeed to construct, but to imagine, something more than a mere map or diagram, something which might even be called a working model of inanimate objects, which was nevertheless very unlike the realities of nature. Of course, the agreement between the action of the model and the behavior of the things it was designed to represent would probably be imperfect, unless the one were a facsimile of the other; but it is conceivable that the correlation of natural phenomena could be imitated, with a large measure of success, by means of an imaginary machine which shared with a map or diagram the characteristic that it was in many ways unlike the things it represented, but might be compared to a model in that the behavior of the things represented could be predicted from that of the corresponding parts of the machine.

We might even go a step further. If the laws of the working of the model could be expressed by abstractions, as, for example, by mathematical formulæ, then, when the formulæ were obtained, the model might be discarded, as probably unlike that which it was made to imitate, as a mere aid in the construction of equations, to be thrown aside when the perfect structure of mathematical symbols was erected.

If this course were adopted we should have given up the attempt to know more of the nature of the objects which surround us than can be gained by direct observation, but might nevertheless have learned how these objects would behave under given circumstances.

We should have abandoned the hope of a physical explanation of the properties of inanimate nature, but should have secured a mathematical description of her operations.

There is no doubt that this is the easiest path to follow. Criticism is avoided if we admit from the first that we cannot go below the surface; cannot know anything about the constitution of material bodies; but must be content with formulating a description of their behavior by means of laws of nature expressed by equations.

But if this is to be the end of the study of nature, it is evident that the construction of the model is not an essential part of the process. The model is used merely as an aid to thinking; and if the relations of phenomena can be investigated without it, so much the better. The highest form of theory—it may be said—the widest kind of generalization, is that which has given up the attempt to form clear mental pictures of the constitution of matter, which expresses the facts and the laws by language and symbols which lead to results that are true, whatever be our view as to the real nature of the objects with which we deal. From this point of view the atomic theory becomes not so much false as unnecessary; it may be regarded as an attempt to give an unnatural precision to ideas which are and must be vague.

Thus, when Rumford found that the

mere friction of metals produced heat in unlimited quantity, and argued that heat was therefore a mode of motion, he formed a clear mental picture of what he believed to be occurring. But his experiments may be quoted as proving only that energy can be supplied to a body in indefinite quantity, and when supplied by doing work against friction it appears in the form of heat.

By using this phraseology we exchange a vivid conception of moving atoms for a colorless statement as to heat energy, the real nature of which we do not attempt to define; and methods which thus evade the problem of the nature of the things which the symbols in our equations represent have been prosecuted with striking success, at all events within the range of a limited class of phenomena. A great school of chemists, building upon the thermodynamics of Willard Gibbs and the intuition of Van't Hoff, have shown with wonderful skill that, if a sufficient number of the data of experiment are assumed, it is possible, by the aid of thermodynamics, to trace the form of the relations between many physical and chemical phenomena without the help of the atomic theory.

But this method deals only with matter as our coarse senses know it; it does not pretend to penetrate beneath the surface.

It is therefore with the greatest respect for its authors, and with a full recognition of the enormous power of the weapons employed, that I venture to assert that the exposition of such a system of tactics cannot be regarded as the last word of science in the struggle for the truth.

Whether we grapple with them, or whether we shirk them; however much or however little we can accomplish without answering them, the questions still force themselves upon us: Is matter what it seems to be? Is interplanetary space full or empty? Can we argue back from the direct impressions of our senses to things which we cannot directly perceive; from the phenomena displayed by matter to the constitution of matter itself?

It is these questions which we are discussing to-night, and we may therefore, as far as the present address is concerned, put aside, once for all, methods of scientific exposition in which an attempt to form a mental picture of the constitution of matter is practically abandoned, and devote ourselves to the inquiries whether the effort to form such a picture is legitimate, and whether we have any reason to believe that the sketch which science has already drawn is to some extent a copy, and not a mere diagram, of the truth.

SUCCESSIVE STEPS IN THE ANALYSIS OF MATTER.

In dealing, then, with the question of the constitution of matter and the possibility of representing it accurately, we may grant at once that the ultimate nature of things is, and must remain, unknown; but it does not follow that immediately below the complexities of the superficial phenomena which affect our senses there may not be a simpler machinery of the existence of which we can obtain evidence, indirect indeed but conclusive.

The fact that the apparent unity which we call the atmosphere can be resolved into a number of different gases is admitted; though the ultimate nature of oxygen, nitrogen, argon, carbonic acid and water vapor is as unintelligible as that of air as a whole, so that the analysis of air may be said to have substituted many incomprehensibles for one.

Nobody, however, looks at the question from this point of view. It is recognized that an investigation into the proximate constitution of things may be useful and successful, even if their ultimate nature is beyond our ken.

Nor need the analysis stop at the first step. Water vapor and carbonic acid, themselves constituents of the atmosphere, are in turn resolved into their elements, hydrogen, oxygen and carbon, which, without a formal discussion of the criteria of reality, we may safely say are as real as air itself.

Now at what point must this analysis stop if we are to avoid crossing the boundary between fact and fiction? Is there any fundamental difference between resolving air into a mixture of gases and resolving an elementary gas into a mixture of atoms and ether?

There are those who cry halt at the point at which we divide a gas into molecules, and their first objection seems to be that molecules and atoms cannot be directly perceived, cannot be seen or handled, and are mere conceptions, which have their uses, but cannot be regarded as realities.

It is easiest to reply to this objection by an illustration.

The rings of Saturn appear to be continuous masses separated by circular rifts. This is the phenomenon which is observed through a telescope. By no known means can we ever approach or handle the rings; yet everybody who understands the evidence now believes that they are not what they appear to be, but consist of minute moonlets, closely packed indeed, but separate the one from the other.

In the first place Maxwell proved mathematically that if a Saturnian ring were a continuous solid or fluid mass it would be unstable and would necessarily break into fragments. In the next place, if it were possible for the ring to revolve like a solid body, the inmost parts would move slowest, while a satellite moves faster the nearer it is to a planet. Now spectroscopic observation, based on the beautiful method of Sir W. Huggins, shows not only that the inner portions of the ring move the more rapidly, but that the actual velocities of the outer and inner edges are in close accord with the theoretical velocities of satellites at like distances from the planet.

This and a hundred similar cases prove that it is possible to obtain convincing evidence of the constitution of bodies between whose separate parts we cannot directly distinguish, and I take it that a physicist who believes in the reality of atoms thinks that he has as good reason for dividing an apparently continuous gas into molecules as he has for dividing the apparently continuous Saturnian rings into satellites. If he is wrong it is not the fact that molecules and satellites alike cannot be handled and cannot be seen as individuals that constitutes the difference between the two cases.

It may, however, be urged that atoms and the ether are alleged to have properties different from those of matter in bulk, of which alone our senses take direct cognizance, and that therefore it is impossible to prove their existence by evidence of the same cogency as that which may prove the existence of a newly discovered variety of matter or of a portion of matter too small or too distant to be seen.

This point is so important that it requires full discussion, but in dealing with it, it is necessary to distinguish carefully between the validity of the arguments which support the earlier and more fundamental propositions of the theory; and the evidence brought forward to justify mere speculative applications of its doctrines which might be abandoned without discarding the theory itself. The proof of the theory must be carried out step by step.

The first step is concerned wholly with some of the most general properties of matter, and consists in the proof that those properties are either absolutely unintelligible, or that, in the case of matter of all kinds, we are subject to an illusion similar to that, the results of which we admit in the

case of Saturn's rings, clouds, smoke, and a number of similar instances. The believer in the atomic theory asserts that matter exists in a particular state; that it consists of parts which are separate and distinct the one from the other, and as such are capable of independent movements.

Up to this point no question arises as to whether the separate parts are, like grains of sand, mere fragments of matter; or whether, though they are the bricks of which matter is built, they have, as individuals, properties different from those of masses of matter large enough to be directly perceived. If they are mere fragments of ordinary matter, they cannot be used as aids in explaining those qualities of matter which they themselves share.

We cannot explain things by things themselves. If it be true that the properties of matter are the product of an underlying machinery, that machinery cannot itself have the properties which it produces, and must, to that extent at all events, differ from matter in bulk as it is directly presented to the senses.

If, however, we can succeed in showing that if the separate parts have a limited number of properties (different, it may be, from those of matter in bulk), the many and complicated properties of matter can, to a considerable extent, be explained as consequences of the constitution of these separate parts; we shall have succeeded in establishing, with regard to quantitative properties, a simplification similar to that which the chemist has established with regard to varieties of matter. The many will have been reduced to the few.

The proofs of the physical reality of the entities discovered by means of the two analyses must necessarily be different. The chemist can actually produce the elementary constituents into which he has resolved a compound mass. No physicist or chemist can produce a single atom separated from all its fellows, and show that it possesses the elementary qualities he assigns to it. The cogency of the evidence for any suggested constitution of atoms must vary with the number of facts which the hypothesis that they possess that constitution explains.

Let us take, then, two steps in their proper order, and inquire, first, whether there is valid ground for believing that all matter is made up of discrete parts; and secondly, whether we can have any knowledge of the constitution or properties which those parts possess.

THE COARSE-GRAINEDNESS OF MATTER.

Matter in bulk appears to be continuous. Such substances as water or air appear to the ordinary observer to be perfectly uniform in all their properties and qualities, in all their parts.

The hasty conclusion that these bodies are really uniform is, nevertheless, unthinkable.

In the first place the phenomena of diffusion afford conclusive proof that matter when apparently quiescent is in fact in a state of internal commotion. I need not recapitulate the familiar evidence to prove that gases and many liquids when placed in communication interpenetrate or diffuse into each other; or that air, in contact with a surface of water, gradually becomes laden with water vapor, while the atmospheric gases in turn mingle with the water. Such phenomena are not exhibited by liquids and gases alone, nor by solids at high temperatures only. Sir W. Roberts-Austen has placed pieces of gold and lead in contact at a temperature of 18° C. After four years the gold had traveled into the lead to such an extent that not only were the two metals united, but, on analysis, appreciable quantities of the gold were detected even at a distance of more than 5 millimeters from the common surface, while within a distance of three-quarters of a millimeter from the

surface gold had penetrated into the lead to the extent of 1 oz. 6 dwts. per ton, an amount which could have been profitably extracted.

Whether it is or is not possible to devise any other intelligible account of the cause of such phenomena, it is certain that a simple and adequate explanation is found in the hypothesis that matter consists of discrete parts in a state of motion, which can penetrate into the spaces between the corresponding parts of the surrounding bodies.

The hypothesis thus framed is also the one which affords a rational explanation of other simple and well-known facts. If matter is regarded as a continuous medium the phenomena of expansion are unintelligible. There is, apparently, no limit to the expansion of matter, or, to fix our attention on one kind of matter, let us say to the expansion of a gas; but it is inconceivable that a continuous material which fills or is present in every part of a given space could also be present in every part of a space a million times as great. Such a statement might be made of a mathematical abstraction; it cannot be true of any real substance or thing. If, however, matter consists of discrete particles, separated from each other either by empty space or by something different from themselves, we can at once understand that expansion and contraction may be nothing more than the mutual separation or approach of these particles.

Again, no clear mental picture can be formed of the phenomena of heat unless we suppose that heat is a mode of motion. In the words of Rumford, "it is extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in the manner the heat was excited and communicated in [his] experiment [on friction] except it be motion."* And if heat be motion, there can be no doubt that it is the fundamental particles of matter which are moving. For the motion is not visible, is not motion of the body as a whole, while diffusion, which is a movement of matter, goes on more quickly as the temperature rises, thereby proving that the internal motions have become more rapid, which is exactly the result which would follow if these were the movements which constitute sensible heat.

Combining, then, the phenomena of diffusion, expansion and heat, it is not too much to say that no hypotheses which make them intelligible have ever been framed other than those which are at the basis of the atomic theory.

Many other considerations also point to the same conclusion. Many years ago Lord Kelvin gave independent arguments, based on the properties of gases, on the constitutions of the surfaces of liquids, and on the electric properties of metals, all of which indicate that matter is, to use his own phrase, coarse-grained—that it is not identical in constitution throughout, but that adjacent minute parts are distinguishable from each other by being either of different natures or in different states.

And here it is necessary to insist that all these fundamental proofs are independent of the nature of the particles or granules into which matter must be divided.

The particles, for instance, need not be different in kind from the medium which surrounds and separates them. It would suffice if they were what may be called singular parts of the medium itself, differing from the rest only in some peculiar state of internal motion or of distortion, or by being in some other way earmarked as distinct individuals. The view that the constitution of matter is atomic may and does receive support from theories in which definite assumptions are made as to the constitution of the atoms; but when, as is

* *Phil. Trans.*, 1798, p. 99.

often the case, these assumptions introduce new and more recondite difficulties, it must be remembered that the fundamental hypothesis—that matter consists of discrete parts, capable of independent motions—is forced upon us by facts and arguments which are altogether independent of what the nature and properties of these separate parts may be.

As a matter of history the two theories, which are not by any means mutually exclusive, that atoms are particles which can be treated as distinct in kind from the medium which surrounds them, and that they are parts of that medium existing in a special state, have both played a large part in the theoretical development of the atomic hypothesis. The atoms of Waterston, Clausius and Maxwell were particles. The vortex-atoms of Lord Kelvin, and the strain-atoms (if I may call them so) suggested by Mr. Larmor, are states of a primary medium which constitutes a physical connection between them, and through which their mutual actions arise and are transmitted.

PROPERTIES OF THE BASIS OF MATTER.

It is easy to show that, whichever alternative be adopted, we are dealing with something, whether we consider it under the guise of separate particles or of differentiated portions of the medium, which has properties different from those of matter in bulk.

For if the basis of matter had the same constitution as matter, the irregular heat movements could hardly be maintained either against the viscosity of the medium or the frittering away of energy of motion which would occur during the collisions between the particles. Thus, even in the case in which a hot body is prevented from losing heat to surrounding objects, its sensible heat should spontaneously decay by a process of self-cooling. No such phenomenon is known, and though on this, as on all other points, the limits of our knowledge are fixed by the uncertainty of experiment, we are compelled to admit that, to all appearance, the fundamental medium, if it exists, is unlike a material medium, in that it is non-viscous; and that the particles, if they exist, are so constituted that energy is not frittered away when they collide. In either case we are dealing with something different from matter itself in the sense that, though it is the basis of matter, it is not identical in all its properties with matter.

The idea therefore that entities exist possessing properties different from those of matter in bulk is not introduced at the end of a long and recondite investigation to explain facts with which none but experts are acquainted. It is forced upon us at the very threshold of our study of nature. Either the properties of matter in bulk cannot be referred to any simpler structure, or that simpler structure must have properties different from those of matter in bulk as we directly knew it—properties which can only be inferred from the results which they produce.

No *à priori* argument against the possibility of our discovering the existence of quasi-material substances, which are nevertheless different from matter, can prove the negative proposition that such substances cannot exist. It is not a self-evident truth that no substance other than ordinary matter can have an existence as real as that of matter itself. It is not axiomatic that matter cannot be composed of parts whose properties are different from those of the whole. To assert that even if such substances and such parts exist no evidence, however cogent, could convince us of their existence is to beg the whole question at issue; to decide the cause before it has been heard.

We must therefore adhere to the stand-

point adopted by most scientific men, *viz.*, that the question of the existence of ultra-physical entities, such as atoms and the ether, is to be settled by the evidence, and must not be ruled out as inadmissible on *à priori* grounds.

On the other hand, it is impossible to deny that, if the mere entry on the search for the concealed causes of physical phenomena is not a trespass on ground we have no right to explore, it is at all events the beginning of a dangerous journey.

The wraiths of phlogiston, caloric, luminiferous corpuscles and a crowd of other phantoms haunt the investigator, and as the grim host vanishes into nothingness he cannot but wonder if his own conceptions of atoms and of the ether

> 'shall dissolve,
> And, like this insubstantial pageant faded,
> Leave not a wrack behind.'

But though science, like Bunyan's hero, has sometimes had to pass through the 'Valley of Humiliation,' the spectres which meet it there are not really dangerous if they are boldly faced. The facts that mistakes have been made, that theories have been propounded, and for a time accepted, which later investigations have disproved, do not necessarily discredit the method adopted. In scientific theories, as in the world around us, there is a survival of the fittest, and Dr. James Ward's unsympathetic account of the blunders of those whose work, after all, has shed glory on the nineteenth century, might *mutatis mutandis* stand for a description of the history of the advance of civilization. "The story of the progress so far," he tells us, "is briefly this: Divergence between theory and fact one part of the way, the wreckage of abandoned fictions for the rest, with an unattainable goal of phenomenal nihilism and ultra-physical mechanism beyond." *

* James Ward, 'Naturalism and Agnosticism,' Vol. I., p. 153.

"The path of progress," says Professor Karl Pearson, "is strewn with the wreck of nations. Traces are everywhere to be seen of the hecatombs of inferior races, and of victims who found not the narrow way to the greater perfection. Yet these dead peoples are, in very truth, the stepping-stones on which mankind has arisen to the higher intellectual and deeper emotional life of to-day." *

It is only necessary to add that the progress of society is directed towards an unattainable goal of universal contentment, to make the parallel complete.

And so, in the one case as in the other, we may leave 'the dead to bury their dead.' The question before us is not whether we too may not be trusting to false ideas, erroneous experiments, evanescent theories. No doubt we are; but, without making an insolent claim to be better than our fathers, we may fairly contend that, amid much that is uncertain and temporary, some of the fundamental conceptions, the root-ideas of science are so grounded on reason and fact that we cannot but regard them as an aspect of the very truth.

Enough has, perhaps, now been said on this point for my immediate purpose. The argument as to the constitution of matter could be developed further in the manner I have hitherto adopted, *viz.*, by series of propositions, the proof of each of which is based upon a few crucial phenomena. In particular, if matter is divided into moving granules or particles, the phenomenon of cohesion proves that there must be mutual actions between them analogous to those which take place between large masses of matter, and which we ascribe to force, thereby indicating the regular, unvarying operation of active machinery which we have not yet the means of adequately understanding. For the moment, I do not wish

* Karl Pearson, 'National Life from the Standpoint of Science,' p. 62.

to extend the line of reasoning that has been followed. My main object is to show that the notion of the existence of ultra-physical entities and the leading outlines of the atomic theory are forced upon us at the beginning of our study of nature, not only by *à priori* considerations, but in the attempt to comprehend the results of even the simplest observation. These outlines cannot be effaced by the difficulties which undoubtedly arise in filling up the picture. The cogency of the proof that matter is coarse-grained is in no way affected by the fact that we may have grave doubts as to the nature of the granules. Nay, it is of the first importance to recognize that, though the fundamental assumptions of the atomic theory receive overwhelming support from a number of more detailed arguments, they are themselves almost of the nature of axioms, in that the simplest phenomena are unintelligible if they are abandoned.

THE RANGE OF THE ATOMIC THEORY.

It would be most unfair, however, to the atomic theory to represent it as depending on one line of reasoning only, or to treat its evidence as bounded by the very general propositions I have discussed.

It is true that as the range of the theory is extended the fundamental conception that matter is granular must be expanded and filled in by supplementary hypotheses as to the constitution of the granules. It may also be admitted that no complete or wholly satisfactory description of that constitution can as yet be given; that perfection has not yet been attained here or in any other branch of science; but the number of facts which can be accounted for by the theory is very large compared with the number of additional hypotheses which are introduced; and the cumulative weight of the additional evidence obtained by the study of details is such as to add greatly to the strength of the conviction that, in its leading outlines, the theory is true.

It was originally suggested by the facts of chemistry, and though, as we have seen, a school of chemists now thrusts it into the background, it is none the less true, in the words of Dr. Thorpe, that 'every great advance in chemical knowledge during the last ninety years finds its interpretation in [Dalton's] theory.'*

The principal mechanical and thermal properties of gases have been explained, and in a large part discovered, by the aid of the atomic theory; and, though there are outstanding difficulties, they are, for the most part, related to the nature of the atoms and molecules, and do not affect the question as to whether they exist.

The fact that different kinds of light all travel at the same speed in interplanetary space, while they move at different rates in matter, is explained if matter is coarse-grained. But to attempt to sum up all this evidence would be to recite a text-book on physics. It must suffice to say that it is enormous in extent and varied in character, and that the atomic theory imparts a unity to all the physical sciences which has been attained in no other way.

I must, however, give a (couple) of instances of the wonderful success which has been achieved in the explanation of physical phenomena by the theory we are considering, and I select them because they are in harmony with the line of argument I have been pursuing.

When a piece of iron is magnetized its behavior is different according as the magnetic force applied to it is weak, moderate or strong. When a certain limit is passed the iron behaves as a non-magnetic substance to all further additions on magnetic force. With strong forces it does and with very weak forces it does not remain mag-

* Thorpe, 'Essays on Historical Chemistry,' 1849, p. 368.

netized when the force ceases to act. Professor Ewing has imitated all the minute details of these complicated properties by an arrangement of small isolated compass needles to represent the molecules. It may fairly be said that as far as this particular set of phenomena is concerned a most instructive working model based on the molecular theory has not only been imagined but constructed.

The next illustration is no less striking. We may liken a crowd of molecules to a fog; but while the fog is admitted by everybody to be made up of separate globules of water, the critics of scientific method are sometimes apt to regard the molecules as mere fictions of the imagination. If, however, we could throw the molecules of a highly rarefied gas into such a state that vapor condensed on them, so that each became the center of a water-drop, till the host of invisible molecules was, as it were, magnified by accretion into a visible mist, surely no stronger proof of their reality could be desired. Yet there is every reason to believe that something very like this has been accomplished by Mr. C. T. R. Wilson and Professor J. J. Thomson.

It is known that it is comparatively difficult to produce a fog in damp air if the mixture consists of air and water-vapor alone. The presence of particles of very fine dust facilitates the process. It is evident that the vapor condenses on the dust particles and that a nucleus of some kind is necessary on which each drop may form. But electrified particles also act as nuclei; for if a highly charged body from which electricity is escaping be placed near a steam jet, the steam condenses; and a cloud is also formed in dust-free air more easily than would otherwise be the case if electricity is discharged into it.

Again, according to accepted theory, when a current of electricity flows through a gas some of the atoms are divided into parts which carry positive and negative charges as they move in opposite directions, and unless this breaking-up occurs a gas does not conduct electricity. But a gas can be made a conductor merely by allowing the Röntgen rays or the radiation given off by uranium to fall upon it. A careful study of the facts shows that it is probable that some of the atoms have been broken up by the radiation, and that their oppositely electrified parts are scattered among their unaltered fellows. Such a gas is said to be ionized.

Thus by these two distinct lines of argument we come to the conclusions: 1st, that the presence of electrified particles promotes the formation of mist, and 2d, that in an ionized gas such electrified particles are provided by the breaking-up of atoms.

The two conclusions will mutually support each other if it can be shown that a mist is easily formed in ionized air. This was tested by Mr. Wilson, who showed that in such air mist is formed as though nuclei were present, and thus in the cloud we have visible evidence of the presence of the divided atoms. If then we cannot handle the individual molecules we have at least some reason to believe that a method is known of seizing individuals, or parts of individuals, which are in a special state, and of wrapping other matter round them till each one is the center of a discrete particle of a visible fog.

I have purposely chosen this illustration, because the explanation is based on a theory—that of ionization—which is at present subjected to hostile criticism. It assumes that an electrical current is nothing more than the movement of charges of electricity. But magnets placed near to an electric current tend to set themselves at right angles to its direction; a fact on which the construction of telegraphic instruments is based. Hence if the theory be true, a similar effect ought to be produced by a

moving charge of electricity. This experiment was tried many years ago in the laboratory of Helmholtz by Rowland, who caused a charged disc to spin rapidly near a magnet. The result was in accord with the theory; the magnet moved as though acted upon by an electric current. Of late, however, M. Crémieu has investigated the matter afresh, and has obtained results which, according to his interpretation, were inconsistent with that of Rowland.

M. Crémieu's results are already the subject of controversy,* and are, I believe, likely to be discussed in the Section of Physics. This is not the occasion to enter upon a critical discussion of the question at issue, and I refer to it only to point out that though, if M. Crémieu's result were upheld, our views as to electricity would have to be modified, the foundations of the atomic theory would not be shaken.

It is, however, from the theory of ions that the most far-reaching speculations of science have recently received unexpected support. The dream that matter of all kinds will some day be proved to be fundamentally the same has survived many shocks. The opinion is consistent with the great generalization that the properties of elements are a periodic function of their atomic weights. Sir Norman Lockyer has long been a prominent exponent of the view that the spectra of the stars indicate the reduction of our so-called elements to simpler forms, and now Professor J. J. Thomson believes that we can break off from an atom a part, the mass of which is not more than one-thousandth of the whole, and that these corpuscles, as he has named them, are the carriers of the negative charge in an electric current. If atoms are thus complex, not only is the *à priori* probability increased that the different structures which we call elements may all be built of similar bricks, but the discovery by Lenard that the ease with which the corpuscles penetrate different bodies depends only on the density of the obstacles, and not on their chemical constitution, is held by Professor Thomson to be 'a strong confirmation of the view that the atoms of the elementary substances are made up of simpler parts, all of which are alike.'* On the present occasion, however, we are occupied rather with the foundations than with these ultimate ramifications of the atomic theory; and having shown how wide its range is, I must, to a certain extent, retrace my steps and return to the main line of my argument.

* See *Phil. Mag.*, July, 1901, p. 144; and *Johns Hopkins University Circulars*, XX., No. 152, May–June, 1901, p. 78.

THE PROPERTIES OF ATOMS AND MOLECULES.

For if it be granted that the evidence that matter is coarse-grained and is formed of separate atoms and molecules is too strong to be resisted, it may still be contended that we can know little or nothing of the sizes and properties of the molecules.

It must be admitted that though the fundamental postulates are always the same, different aspects of the theory, which have not in all cases been successfully combined, have to be developed when it is applied to different problems; but in spite of this there is little doubt that we have some fairly accurate knowledge of molecular motions and magnitudes.

If a liquid is stretched into a very thin film, such as a soap bubble, we should expect indications of a change in its properties when the thickness of the film is not a very large multiple of the average distance between two neighboring molecules. In 1890 Sohncke† detected evidence of such a

* For the most recent account of this subject see an article on 'Bodies Smaller than Atoms,' by Professor J. J. Thomson in the *Popular Science Monthly* (The Science Press), August, 1901.

† *Wied. Ann.*, 1890, XL., pp. 345–355.

change in films of average thickness of 106 millionths of a millimeter ($\mu\mu$), and quite recently Rudolph Weber found it in an oil-film when the thickness was 115 $\mu\mu$.*

Taking the mean of these numbers and combining the results of different variants of the theory we may conclude that a film should become unstable and tend to rupture spontaneously somewhere between the thicknesses of 110 and 55 $\mu\mu$, and Professor Reinold and I found by experiment that this instability is actually exhibited between the thicknesses of 96 and 45 $\mu\mu$.† There can therefore be little doubt that the first approach to molecular magnitude is signalled when the thickness of a film is somewhat less than 100 $\mu\mu$, or 4 millionths of an inch.

Thirteen years ago I had the honor of laying before the Chemical Society a résumé of what was then known on these subjects,‡ and I must refer to that lecture or to the most recent edition of O. E. Meyer's work on the kinetic theory of gases§ for the evidence that various independent lines of argument enable us to estimate quantities very much less than 4 millionths of an inch, which is perhaps from 500 to 1,000 times greater than the magnitude which, in the present state of our knowledge, we can best describe as the diameter of a molecule.

Confining our attention, however, to the larger quantities, I will give one example to show how strong is the cumulative force of the evidence as to our knowledge of the magnitudes of molecular quantities.

We have every reason to believe that though the molecules in a gas frequently collide with each other, yet in the case of the more perfect gases the time occupied in collisions is small compared with that in which each molecule travels undisturbed by its fellows. The average distance traveled between two successive encounters is called the mean free path, and, for the reason just given, the question of the magnitude of this distance can be attacked without any precise knowledge of what a molecule is, or of what happens during an encounter.

Thus the mean free path can be determined, by the aid of the theory, either from the viscosity of the gas or from the thermal conductivity. Using figures given in the latest work on the subject,* and dealing with one gas only, as a fair sample of the rest, the lengths of the mean free path of hydrogen as determined by these two independent methods differ only by about 3 per cent. Further, the mean of the values which I gave in the lecture already referred to differed only by about 6 per cent. from the best modern result, so that no great change has been introduced during the last thirteen years.

It may, however, be argued that these concordant values are all obtained by means of the same theory, and that a common error may affect them all. In particular, some critics have of late been inclined to discredit the atomic theory by pointing out that the strong statements which have sometimes been made as to the equality, among themselves, of atoms or molecules of the same kind may not be justified, as the equality may be that of averages only, and be consistent with a considerable variation in the sizes of individuals.

Allowing this argument more weight than it perhaps deserves, it is easy to show that it cannot affect seriously our knowledge of the length of the mean free path.

Professor George Darwin † has handled the problem of a mixture of unequal spher-

* *Annalen der Physik*, 1901, IV., pp. 706–721.

† *Phil. Trans.*, 1893, 184, pp. 505–529.

‡ *Chem. Soc. Trans.*, LIII., March, 1888, pp. 222–262.

§ 'Kinetic Theory of Gases,' O. E. Meyer, 1899. Translated by R. E. Baynes.

* Meyer's 'Kinetic Theory of Gases' (see above).

† *Phil. Trans.*, 180.

ical bodies in the particular case in which the sizes are distributed according to the law of errors, which would involve far greater inequalities than can occur among atoms. Without discussing the precise details of his problem it is sufficient to say that in the case considered by him the length of the mean free path is $\frac{7}{11}$ of what it would be if the particles were equal. Hence were the inequalities of atoms as great as in this extreme case, the reduction of the mean free path in hydrogen could only be from 185 to 119 $\mu\mu$; but they must be far less, and therefore the error, if any, due to this cause could not approach this amount. It is probably inappreciable.

Such examples might be multiplied but the one I have selected is perhaps sufficient to illustrate my point, *viz.*, that considerable and fairly accurate knowledge can be obtained as to molecular quantities by the aid of theories the details of which are provisional, and are admittedly capable of improvement.

IS THE MODEL UNIQUE?

But the argument that a correct result may sometimes be obtained by reasoning on imperfect hypotheses raises the question as to whether another danger may not be imminent. To be satisfactory our model of nature must be unique, and it must be impossible to imagine any other which agrees equally well with the facts of experiment. If a large number of hypotheses could be framed with equal claims to validity, that fact would alone raise grave doubts as to whether it were possible to distinguish between the true and the false. Thus Professor Poincaré has shown that an infinite number of dynamical explanations can be found for any phenomenon which satisfies certain conditions. But though this consideration warns us against the too ready acceptance of explanations of isolated phenomena, it has no weight against a theory which embraces so vast a number of facts as those included by the atomic theory. It does not follow that, because a number of solutions are all formally dynamical, they are therefore all equally admissible. The pressure of a gas may be explained as the result of a shower of blows delivered by molecules, or by a repulsion between the various parts of a continuous medium. Both solutions are expressed in dynamical language; but one is, and the other is not, compatible with the observed phenomena of expansion. The atomic theory must hold the field until another can be found which is not inferior as an explanation of the fundamental difficulties as to the constitution of matter, and is, at the same time, not less comprehensive.

On the whole, then, the question as to whether we are attempting to solve a problem which has an infinite number of solutions may be put aside until one solution has been found which is satisfactory in all its details. We are in a sufficient difficulty about that to make the rivalry of a second of the same type very improbable.

THE PHENOMENA OF LIFE.

But it may be asked—nay, it has been asked—may not the type of our theories be radically changed? If this question does not merely imply a certain distrust in our own powers of reasoning, it should be supported by some indication of the kind of change which is conceivable.

Perhaps the chief objection which can be brought against physical theories is that they deal only with the inanimate side of nature, and largely ignore the phenomena of life. It is therefore in this direction, if in any, that a change of type may be expected. I do not propose to enter at length upon so difficult a question, but, however we may explain or explain away the characteristics of life, the argument for the truth of the atomic theory would only be

affected if it could be shown that living matter does not possess the thermal and mechanical properties, to explain which the atomic theory has been framed. This is so notoriously not the case that there is the gravest doubt whether life can in any way interfere with the action within the organism of the laws of matter in bulk belonging to the domain of mechanics, physics, and chemistry.

Probably the most cautious opinion that could now be expressed on this question is that, in spite of some outstanding difficulties which have recently given rise to what is called Neovitalism, there is no conclusive evidence that living matter can suspend or modify any of the natural laws which would affect it if it were to cease to live. It is possible that though subject to these laws the organism while living may be able to employ, or even to direct, their action within itself for its own benefit, just as it unquestionably does make use of the processes of external nature for its own purposes; but if this be so, the seat of the controlling influence is so withdrawn from view that on the one hand its very existence may be denied, while, on the other hand, Professor Haeckel, following Vogt, has recently asserted that "matter and ether are not dead, and only moved by extrinsic force; but they are endowed with sensation and will; they experience an inclination for condensation, a dislike for strain; they strive after the one and struggle against the other."*

But neither unproved assertions of this kind nor the more refined attempts that have been made by others to bring the phenomena of life and of dead matter under a common formula touch the evidence for the atomic theory. The question as to whether matter consists of elements capable of independent motion is prior to and independent of the further questions as to what these elements are, and whether they are alive or dead.

The physicist, if he keeps to his business, asserts, as the bases of the atomic theory, nothing more than that he who declines to admit that matter consists of separate moving parts must regard many of the simplest phenomena as irreconcilable and unintelligible, in spite of the fact that means of reconciling them are known to everybody, in spite of the fact that the reconciling theory gives a general correlation of an enormous number of phenomena in every branch of science, and that the outstanding difficulties are connected, not so much with the fundamental hypotheses that matter is composed of distinguishable entities which are capable of separate motions as with the much more difficult problem of what these entities are.

On these grounds the physicist may believe that, though he cannot handle or see them, the atoms and molecules are as real as the ice crystals in a cirrus cloud which he cannot reach; as real as the unseen members of a meteoric swarm whose death-glow is lost in the sunshine, or which sweep past us, unentangled, in the night.

If the confidence that his methods are weapons with which he can fight his way to the truth were taken from the scientific explorer, the paralysis which overcomes those who believe that they are engaged in a hopeless task would fall upon him.

Physiology has specially flourished since physiologists have believed that it is possible to master the physics and chemistry of the framework of living things, and since they have abandoned the attitude of those who placed in the foreground the doctrine of the vital force. To supporters of that doctrine the principle of life was not a hidden directing power which could perhaps whisper an order that the flood-gates of reservoirs of energy should now be opened

* 'Riddle of the Universe' (English translation), 1900, p. 380.

and now closed, and could, at the most, work only under immutable conditions to which the living and dead must alike submit. On the contrary, their vital force pervaded the organism in all its parts. It was an active and energetic opponent of the laws of physics and chemistry. It maintained its own existence not by obeying but by defying them; and though destined to be finally overcome in the separate campaigns of which each individual living creature is the scene, yet like some guerilla chieftain it was defeated here only to reappear there with unabated confidence and apparently undiminished force.

This attitude of mind checked the advance of knowledge. Difficulty could be evaded by a verbal formula of explanation which in fact explained nothing. If the mechanical, or physical, or chemical causes of a phenomenon did not lie obviously upon the surface, the investigator was tempted to forego the toil of searching for them below; it was easier to say that the vital force was the cause of the discrepancy, and that it was hopeless to attempt to account for the action of a principle which was incomprehensible in its nature.

For the physicist the danger is no less serious though it lies in a somewhat different direction. At present he is checked in his theories by the necessity of making them agree with a comparatively small number of fundamental hypotheses. If this check were removed his fancy might run riot in the wildest speculations, which would be held to be legitimate if only they led to formulæ in harmony with facts. But the very habit of regarding the end as everything, and the means by which it was attained as unimportant, would prevent the discovery of those fragments of truth which can only be uncovered by the painful process of trying to make inconsistent theories agree, and using all facts, however remote, as the tests of our central generalization.

"Science," said Helmholtz, "Science, whose very object it is to comprehend Nature, must start with the assumption that Nature is comprehensible." And again: "The first principle of the investigator of Nature is to assume that Nature is intelligible to us, since otherwise it would be foolish to attempt the investigation at all." These axioms do not assume that all the secrets of the universe will ultimately be laid bare, but that a search for them is hopeless if we undertake the quest with the conviction that it will be in vain. As applied to life they do not deny that in living matter something may be hidden which neither physics nor chemistry can explain, but they assert that the action of physical and chemical forces in living bodies can never be understood, if at every difficulty and at every check in our investigations we desist from further attempts in the belief that the laws of physics and chemistry have been interfered with by an incomprehensible vital force. As applied to physics and chemistry they do not mean that all the phenomena of life and death will ultimately be included in some simple and self-sufficing mechanical theory; they do mean that we are not to sit down contented with paradoxes such as that the same thing can fill both a large space and a little one; that matter can act where it is not, and the like, if by some reasonable hypothesis, capable of being tested by experiment, we can avoid the acceptance of these absurdities. Something will have been gained if the more obvious difficulties are removed, even if we have to admit that in the background there is much that we cannot grasp.

THE LIMITS OF PHYSICAL THEORIES.

And this brings me to my last point. It is a mistake to treat physical theories in general, and the atomic theory in particular, as though they were parts of a scheme

which has failed if it leaves anything unexplained, which must be carried on indefinitely on exactly the same principles, whether the ultimate results are, or are not, repugnant to common sense.

Physical theories begin at the surface with phenomena which directly affect our senses. When they are used in the attempt to penetrate deeper into the secrets of nature it is more than probable that they will meet with insuperable barriers, but this fact does not demonstrate that the fundamental assumptions are false, and the question as to whether any particular obstacle will be forever insuperable can rarely be answered with certainty.

Those who belittle the ideas which have of late governed the advance of scientific theory too often assume that there is no alternative between the opposing assertions that atoms and the ether are mere figments of the scientific imagination, or that, on the other hand, a mechanical theory of the atoms and of the ether, which is now confessedly imperfect, would, if it could be perfected, give us a full and adequate representation of the underlying realities.

For my own part I believe that there is a *via media*.

A man peering into a darkened room, and describing what he thinks he sees, may be right as to the general outline of the objects he discerns, wrong as to their nature and their precise forms. In his description fact and fancy may be blended, and it may be difficult to say where the one ends and the other begins; but even the fancies will not be worthless if they are based on a fragment of truth, which will prevent the explorer from walking into a looking-glass or stumbling over the furniture. He who saw 'men as trees walking' had at least a perception of the fundamental fact that something was in motion around him.

And so, at the beginning of the twentieth century, we are neither forced to abandon the claim to have penetrated below the surface of nature, nor have we, with all our searching, torn the veil of mystery from the world around us.

The range of our speculations is limited both in space and time: in space, for we have no right to claim, as is sometimes done, a knowledge of the 'infinite universe'; in time, for the cumulative effects of actions which might pass undetected in the short span of years of which we have knowledge, may, if continued long enough, modify our most profound generalizations. If some such theory as the vortex-atom theory were true, the faintest trace of viscosity in the primordial medium would ultimately destroy matter of every kind. It is thus a duty to state what we believe we know in the most cautious terms, but it is equally a duty not to yield to mere vague doubts as to whether we can know anything.

If no other conception of matter is possible than that it consists of distinct physical units—and no other conception has been formulated which does not blur what are otherwise clear and definite outlines—if it is certain, as it is, that vibrations travel through space which cannot be propagated by matter, the two foundations of physical theory are well and truly laid. It may be granted that we have not yet framed a consistent image either of the nature of the atoms or of the ether in which they exist; but I have tried to show that in spite of the tentative nature of some of our theories, in spite of many outstanding difficulties, the atomic theory unifies so many facts, simplifies so much that is complicated, that we have a right to insist—at all events till an equally intelligible rival hypothesis is produced—that the main structure of our theory is true; that atoms are not merely helps to puzzled mathematicians, but physical realities.

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*A NOTABLE FACTOR OF SOCIAL DEGENERATION.**

The subject to which I propose to call your attention cannot be said to be a new one, though I do not think that it has ever been presented before this Section. I wish to speak for a short time on one of the phases of social anthropology, in which I am very greatly interested. My theme is the problem of the feeble-minded. This term is now generally used to include all persons from those with weak minds to the most abject idiot. Perhaps most of us have met with a few individuals of this class. Almost every community contains one or more of these degenerates. The aggregate for our country, however, makes a mighty host. We do not know how many feeble-minded persons there are in the United States. The census of 1890 gives 95,571 individuals of of that kind. From Pennsylvania there were reported that year 8,753; Ohio, 8,035; Indiana, 5,568; Iowa, 3,319; Kansas, 2,039; Colorado, 192. What the increase since then has been we do not know. The present census does not give any figures on this point; therefore any effort to ascertain the number can be but an estimate. These feeble-minded persons are distributed throughout our land, not in the same proportion everywhere. They are not so notable in some localities as in others. In some places they are so few or inconspicuous as scarcely to be recognized. On the contrary, elsewhere their presence is strikingly manifest, and they, in one way or another, make a deep impression upon society that must endure through succeeding generations. The feeble-minded are found under many conditions. There are children and men and women. It is as children and as adults in their more active years that most of us know them best. Our social organization is made up of many factors. Some are constructive, some destructive. The feeble-minded are a disturbing element. Their life is a degenerating social force.

Some of the children with stronger mental powers enter the public schools. They may make some progress for a time, but whether they do or not, they must soon drop behind because they are unable to keep up with the work. Others roam the streets; the boys become the butt of the neighborhood, they are led into pranks, too often into vices, and seem to possess a peculiar tendency to immorality. The girls, many of them strong, well-appearing, with no one to teach them aright, and without strength of mind to protect themselves against the temptations which surround them, too early and too often fall into vice. "It is impossible to think of the evil of feeble-mindedness without heeding the curse of vice and illegitimacy which are its inevitable accompaniments. In the feeble-minded person the animal passions are usually present and are often abnormally developed, while will and reason, which should control and repress them, are absent. The feeble-minded woman, thus lacking the protection which should be her birthright, falls easily into vice. She cannot in her weakness resist the persuasions and temptations which beset her. When her baser passions are strong, she must oppose not only the influences from without but her own dominating desires. She is not to be condemned and punished, but rather to be pitied and helped in every possible manner." (Bicknell, Proc. Fourth Indiana State Conf. of Char. & Corr., 1895, p. 64.) Many of these poor creatures are easily attracted by an immoral life. Once begun, the pace is rapid, the course is always the same. It is impossible to tell or even to conceive of the depths of degradation to which they go. Dr. Kerlin, in

* Address of the Vice-President and Chairman of Section H, Anthropology, of the American Association for the Advancement of Science, Denver meeting, August, 1901.

1884, in his report to the National Conference of Charities and Correction speaks of moral imbecility, showing its blighting and demoralizing effects. He shows how crime, vice and depravity are spread by neglected feeble-minded or imbecile persons. He says, "There is no field in political economy which can be worked to better advantage for the diminution of crime, pauperism and insanity than that of idiocy." (Proc. Nat. Conf. of Char. and Cor., 1884, pp. 257 and 258.)

One perverted feeble-minded woman can spread throughout a community an immoral pestilence which will affect the homes of all classes, even the most intelligent and refined. The sight of such conditions or a knowledge of them must have a deadening effect upon the finer sensibilities of all.

These defectives usually also become dependents for a part of, if not all, the time. They may depend upon private charities or, when possible, upon the overseer of the poor. They frequently live in the poorest quarters of our towns and cities amid squalor and dirt, or occupy miserable huts in the least desirable localities of rural communities. It is not unusual for two or more families to live near each other or associate together. Marital ties are often lightly regarded. Frequently such bonds have not been entered into.

When these feeble-minded persons become helpless or learn the habit of regular public dependence, they find their way to poor asylums, the children being placed in such orphans' homes as will accept them. To one who visits the poor asylums and orphans' homes where they are received, the idiotic and feeble-minded are striking objects. In every one of the ninety-two poor asylums in my own State, Indiana, there are to be found inmates of this class, the greatest number in any one institution being 25; the lowest, 2. In many, their presence is emphasized by pitiable cases, individuals who are almost uncontrollable, or by infants, the offspring—in most cases the illegitimate offspring—of parents, one or both of whom are feeble-minded. The records at hand show that there are 970 feeble-minded persons in the Indiana poor asylums. (Rept. Board of State Char. of Indiana, 1900, p. 73.) Almost all these are adults. Many are in some degree helpless and all require more or less care. They have grown up without discipline; they lack such training as is possible with their dwarfed minds or strong hands; they are not only incapable of earning their own support, but, in a large number of instances, are the objects of continual anxiety to those in charge. This is particularly the case with feeble-minded women. Four hundred and eighty unfortunates of this sex are to be found in our county asylums, comprising 49.5 of their total feeble-minded population. Under our system of care it is only by the utmost watchfulness that the sexes are kept apart. Where proper facilities for sex separation are wanting, or the overwatch is not strict, there is to be found a continual increase of feeble-mindedness. This brings an increasing burden of expense upon the tax-payers in such counties.

I am compelled to speak specifically of Indiana, because we know more of the facts concerning conditions that exist there than we do of those elsewhere.

From information received, however, it is believed that they are not materially different from those existing in other States similarly situated. Perhaps in a general way the conditions there may be said to be the average of what is true of all our States.

To quite a large number of our poor asylums the inmates often come and go at will. The absence of the feeble-minded is especially noted during the summer season. They then go to visit friends or wander

about the country. Any kind of shelter will answer their purpose and food is easily obtained. Quite a number of the women return to the poor asylum to become mothers.

In a certain county in the southern part of the State is a family of sixteen persons, representing three generations. Twelve of its members are the direct descendants of a feeble-minded blind man and his feeble-minded, partially blind, wife. The husband and wife have been inmates of the poor asylum off and on for thirty-five years. Generally wintering in the institution, they spend the summer roaming about the country, living in the woods. In unfavorable weather they seek an old hut or rail pen for shelter. They are said to make a bed of leaves or straw and live on what they can beg, supplemented by wild fruits and nuts. They have a feeble-minded daughter who is also partially blind. She has been twice married and has borne two feeble-minded daughters and three feeble-minded sons. Another feeble-minded and partially blind daughter has spent the greater part of the last twenty-two years in the poor asylum of an adjacent county and has been the mother of four illegitimate children. In this family of sixteen persons, nine are feeble-minded (three of these being also partially blind) and four are known to be illegitimate.

In an adjoining county are a husband and wife, both degenerates, who make the poor asylum their home in winter and live elsewhere in summer. It is no uncommon thing, in the spring following these wanderings, to have the family increased by a little mite of humanity which does not seem as if it could live. Many such children do live, however. This woman has borne eleven children and six of them are alive. One summer the family lived in a little shed built of short boards obtained from dry-goods boxes, old tin and carpets, along the railroad right-of-way, and obtained its living principally from begging. This family has just made a beginning. How extensive it may become depends upon what measures are taken. It has probably been an expense of $1,000 per year to the county.

Occasionally the children of normal parents are feeble-minded. As Mr. Bicknell has well said, there is no method of diverting the course. While it is easily possible for parents of normal faculties through dissipation, vice or disease to produce feeble-minded offspring, there seems to be no method by which the tendency can be reversed and the degeneration, thus easily accomplished, displaced by regeneration and restoration in succeeding generations. (Fifth Rept. of Indiana Board of State Charities, 1894, page 51.)

Usually, and in a large number of cases, feeble-minded children are the offspring of feeble-minded parents. It is equally true that in the majority of cases the children of feeble-minded parents are feeble-minded.

From what has been said may be gathered that the question before us presents two notable evils:

(*a*) The increasing number of illegitimate children of feeble-minded parents.

(*b*) The inheritance of feeble-mindedness.

In the office of the Board of State Charities of Indiana there has been collected, from every reliable source, during the past twelve years, a great mass of material relating to this group of defectives. It embraces much that has been gathered by the Indiana School for Feeble-minded Youth especially through the efforts of Mr. Alexander Johnson, its able superintendent. In addition, it contains such information as could be obtained from the Poor Asylum and Orphans' Home records and from the township trustees who are *ex-officio* overseers of the poor. I know of no such a series of records nor one so conveniently arranged. Mr. Ernest P. Bicknell, formerly the Secre-

tary of the Board of State Charities, some years ago prepared two papers based upon a part of this material. (Proc. Indiana State Conf. of Char. and Cor., 1895, p. 60. Proc. National Conf. of Char. and Cor., 1887, p. 219.)

With the fuller amount of data from these records at hand I have thought to present some illustrations obtained from it at this time.

Perhaps I may say a word as to the method of registration used in this work. From all our institutions regular reports are required. Some of these are made monthly, others quarterly. They are arranged with headings for all the principal facts in the individual and family history of each inmate. It is desired to have them filled as fully as the information obtained will permit. In addition to the regular institution records, information is sought as to the age, nativity, sex, color, mental and physical condition, and whether illegitimate. If parents are known we ask for their names and specific information as to whether either is affected with insanity, feeble-mindedness, deafness, blindness, paralysis, or whether either was a pauper, criminal or drunkard. This information, when obtained, is transferred to a card registration, where the cards are kept in duplicate; one series arranged alphabetically, the other by institutions. To the information at hand every fragment that is learned is added.

I have taken from these records some information concerning 511 families in which there is known to be feeble-mindedness. If there was any question regarding any family it was omitted. No such collection of these families has heretofore been reported upon. The number of persons known to be represented in them is 1,924. This is an average of 3.76 persons in each family. 1,343 of these persons are supported in public institutions. It is known, however, that these are not all the family representatives. They are the family members of whom we have accurate information. In it are included not only direct descendants, but those related by marriage.

Of this number of persons, 889, 46.2 per cent., were men; 1,035, 53.7 per cent., were women. 1,249—64.9 per cent., 532 men and 717 women, were feeble-minded; 54, 21 men and 33 women, were insane; 44, 25 men and 19 women, were otherwise defective. These last include blind, deaf, paralytics and epileptics. 577, 311 men and 268 women, were normal or their defectiveness was unknown. Every person known concerning whom positive information was not was included in this latter group. In a number of cases there are combinations of defectiveness. One was insane and deaf, another feeble-minded, deaf and epileptic. Consequently, if we undertake to separate them we find there are 79 epileptics, 31 men and 48 women; 35 blind, 17 men and 18 women; 21 deaf, 6 men and 15 women; 19 paralytics, 8 men and 11 women; with combined mental and physical defects 101, 34 men and 67 women. Of these family members, 267, 13.8 per cent., 141 men and 126 women, are known to have been illegitimate.

What about the parentage of these individuals? In a large number of cases the characteristics are unknown. It is a matter of record that in 1,042 cases (over 54 per cent. of the whole) either one or both parents were defective. Of these in the cases of 666—348 males and 318 females, the mother was defective. In the case of 151, 83 males and 68 females, the father was defective, the mother unknown or normal. Both parents were defective in 225 instances, 122 males and 103 females. It will be seen that the records show the mother defective in 34.6 per cent. of the total number of cases noted herein, while only 7.8 per cent. of the fathers were defective, and both parents were defective

A Table of 511 Feeble-minded Families Containing 1,924 Persons.

	Whole number.	In public institutions.	Feeble-minded.	Insane.	Epileptic.	Blind.	Deaf.	Feeble-minded and epileptic.	Feeble-minded, paralytic and epileptic.	Feeble-minded and blind.	Feeble-minded and paralytic
Males.	889	617	499	20	8	10	3	21	1	6	3
Females.	1,035	726	652	31	10	2	5	31	3	14	7
Total.	1,924	1,343	1,151	51	18	12	8	52	4	20	10

	Feeble-minded and deaf.	Feeble-minded, deaf and epileptic.	Feeble-minded, blind and epileptic.	Blind and paralytic.	Paralytic.	Blind and epileptic.	Insane and epileptic.	Insane and deaf.	Unknown or normal.	Illegitimate.	Total.
Males.	1	1		1	3			1	311	141	889
Females.	8	1	1		1	1	1	1	266	126	1,035
Total.	9	2	1	1	4	1	1	2	577	267	1,924

Parentage of Above 1,924 Persons.

	Mother f. m. Father unk. or normal.	Mother f. m. and ep. Father unk. or normal.	Mother f. m. and bl. Father unk. or normal.	Mother f. m. Father f. m. and ep.	Mother f. m. and ep. Father f. m.	Mother f. m. and df. Father unk. or normal.	Mother f. m. and par. Father unk. or normal.	Mother f. m. Father par.	Mother f. m. Father bl.	Mother f. m. Father insane.	Mother f. m. and bl. Father unk. or normal.	Mother insane. Father unk. or normal.	Mother blind. Father unk. or normal.	Mother ep. Father unk. or normal.	Mother insane. Father f. m.
Males.	307	4	2	3	1		1		8	3	2	23	4	4	14
Females.	289	7	3	7		1	1	2	7	2		14		2	9
Total.	596	11	5	10	1	1	2	2	15	5	2	37	4	6	23

	Mother ep. Father f. m.	Mother unk. or normal. Father f. m.	Mother unk. or normal. Father ep.	Mother ins. and ep. Father unk. or normal.	Mother unk. or normal. Father par.	Mother unk. or normal. Father f. m. and bl.	Mother unk. or normal. Father insane.	Mother unk. or normal. Father blind.	Mother ep. Father f. m. and bl.	Parents insane.	Parents f. m. and bl.	Parents related.	Parents D. and D.	Parents unknown or normal.	Parents f. m.
Males.	1	75	2	1		2	3	1	1	5		10	1	326	85
Females.		61	1	1	2		3	1	1	2	2	12	1	534	70
Total.	1	136	3	2	2	2	6	2	2	7	2	22	2	860	155

Feeble-mindedness and Related Defects, Together with Illegitimacy in Five Hundred and Eleven Families.

	Whole number.	Feeble-minded.	Epileptic.	Insane.	Blind.	Deaf.	Paralytic.	Illegitimate.
Males.	889	532	31	21	17	6	8	141
Females.	1,035	717	48	33	18	15	11	126
Total.	1,924	1,249	79	54	35	21	19	267
Number of families.	511							
Average number of persons to each family.	3.76	1.54						
Percent. of whole number		64.9	4.1	2.8	1.8	1.	.9	13.8
Percentage of males.		59.8	3.5	2.3	1.9	.6	.9	15.8
Percentage of females.		69.3	4.6	3.1	1.7	1.4	1.	12.1

in 11.6 per cent. instances. One cause of this difference, perhaps the chief one, is that the mothers, for various reasons which will occur to you, are often known when the fathers are not. The parents of 860 of the 1,924 children, 326 men and 534 women, an aggregate of 44.6 per cent., were either unknown or were known to be normal. In but 22 instances (1.1 per cent.) were the parents reported to be relatives. This was true in the case of 10 men and 12 women.

The physical and mental condition of the parents of these 889 males is more specifically given as follows:

Mother defective, father unknown or normal	348	39.1%
Father defective, mother unknown or normal	83	9.3%
Both parents defective	122	13.7%
Parents unknown or normal	326	36.6%
Parents related	10	1.1%
	889	99.8%

141, or 15.8 per cent., of the males are illegitimate.

The physical and mental condition of the parents of these 1,035 females more particularly stated is as follows:

Mother defective, father normal or unknown	318	30.7%
Father defective, mother normal or unknown	68	6.5%
Both parents defective	103	9.9%
Parents unknown or normal	534	51.5%
Parents related	12	1.1%
	1,035	99.7%

('Defective' in the above means either mentally or physically defective.)

Of the 717 feeble-minded women, 163, or 22 per cent., have had illegitimate children. These 163 women have had 248 children, an average of 1.52 each. They range in number from 1 to 8 to the mother.

Perhaps it is well to refer to a few illustrations of the ancestors of the persons whom we have been discussing.

In one of the county poor asylums of Indiana, years ago, were a man and his wife, who are reported to have been of a low grade of intelligence, if not actually feeble-minded. The direct descendants of this couple, with those who entered the family through marriage, number 67, comprising three generations. One of the men, who is fairly bright, has raised a good family; another is an intelligent barber; two men have served in the army, but the majority of the family are feeble-minded, illiterate and of low morals, and their history is one of drunkenness, prostitution and crime. The marriage relation has been lightly regarded, and doubtless many of the unions were those of common law. Some of these persons are self-supporting, but a much larger number of them are or have been supported by the public in county or state institutions.

One woman I recall is the mother of eleven children, ten of them by one husband, one by another. A feeble-minded man whose history is known to us, was father of twenty children but was married several times.

Another group of 241 families in which there are two or more generations of feeble-mindedness has 970 persons who are blood relations, that is an average of 4.02 to each family. Of these families, 221 have two generations of feeble-mindedness, sixteen have three generations, three have four generations and one has five generations. The number of direct descendants who are feeble-minded is known to be 726. That is to say, 74.8 per cent. are feeble-minded. Does anything else reproduce itself so surely? In addition to this there are 25 who show other evidences of defectiveness. But 197 are normal or their mental and physical condition is unknown.

In the first generation 103 men and 203 women (306) were the parents of 248 children. Of these 84 were males and 164 were females. It is observed that almost twice as many women as men were known

as parents in the first generation. The reason is the women were principally poor asylum inmates who were permitted to leave the institution and either live among relatives of a similar stage of mentality or roam the country. They returned to the poor asylum as a maternity house and nothing was learned or recorded of the paternity of many of the children.

persons, 304 males and 224 females. Of these, 26 were parents of the third generation. Of the latter seven were parents of the fourth generation. From it came the single parent of the fifth generation. In the first generation there were 267 individuals of 306, or 87 per cent., who were feeble-minded; in the second generation 386 of 548, or 70 per cent., were so recorded; in the

A Table of 241 Families Each containing Two or More Generations of Feeble-mindedness Represented by 970 Individuals.

No. families of	2	generations of	feeble-mindedness			221
"	"	" 3	"	"	"	16
"	"	" 4	"	"	"	3
"	"	" 5	"	"	"	1
						241

Total No. of persons 970. Average to each family 4.02.

	Total No. of persons.		F. M.		Ins.		Ep.		Df.		Bl.		F. M. & Df.		F. M. & Ep.		F. M. & Par.		F. M. & Bl.		F.M.Bl. & Ep.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
1st generation.	103	203	84	164	5	17	1	1			3	1		1		3	1	3	3	6		
2d "	304	244	199	157	4	5	2	1		1	2			3	8	11		1		3		1
3d "	48	47	25	31			1								2					1		
4th "	9	11	7	6																		
5th "	1		1																			
Total.	465	505	316	358	9	22	4	2		1	5	1		4	10	14	1	4	3	10		1

	F. M., Par. & Ep.		F.M., Df. & Ep.		Par.		Ins. & Ep.		Ins. & Df.		Unk. or Normal.		Illegit.		
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	
1st generation.		1		1	1			1			5	4		3	
2d "	1	1	1							1	87	59	46	26	Parents of 3d generation, 26
3d "											20	15	15	15	" " 4th " 7
4th "											2	5	1		" " 5th " 1
5th "													1		
Total.	1	2	1	1	1			1		1	114	83	63	44	

Most of the families obviously are of two generations. The child and parent are reported, and often nothing has been learned of an earlier ancestor. Where there are three or four generations some of the older members are dead, so that the amount of information concerning them is scant. On the other hand the later generation is represented by one or more children, many of them so young that their mental state cannot be determined.

In the second generation there were 548

third generation 59 of 95, or 62 per cent., were so noted; in the fourth generation 13 of 20 cases, or 65 per cent., were given as feeble-minded. In the fifth generation the single representative is reported as feeble-minded. The aggregate showing, as noted, is that 74.8 per cent. of the descendants of these feeble-minded ancestors are feeble-minded. Other defects among the children are noted as follows: insane, 3.4 per cent.; epileptic, 3.8 per cent.; blind, 2 per cent.; deaf, 8 per cent.; paralysis, 9 per cent.;

both mentally and physically defective, 5.5 per cent. 107 or 11 per cent. were reported as illegitimate.

It will be observed that the feeble-minded and blind are more common than any other combination in the first generation, while in the second and third generations there are more feeble-minded and epileptics.

In one neighboring county a feeble-minded woman, who, according to the records in our office, has been in the poor asylum over twenty years, was the mother of two daughters, to whom she transmitted her mental defect. One of these feeble-minded daughters, Rachel, has been twice married, and has borne eleven children, three of whom are now dead. Her second union was with a negro. Her children are very ignorant, but so far our records do not show that they have been inmates of any public institution, with the exception of one son, who has been in prison. The other daughter, Kate, had four children, all girls, two feeble-minded and two illegitimate. The two feeble-minded daughters have spent much of their lives in the county poor asylum. One of them, Nancy, became the third wife of a feeble-minded, paralytic man, and one son and three feeble-minded daughters were born to her. Her husband's second wife had a feeble-minded daughter, who married an insane man, and they have one child, a son. Nancy's feeble-minded sister, Lou, married a feeble-minded man, and three daughters and two sons have been the result of this marriage. One of the daughters is feeble-minded. One of the sons, also feeble-minded, is a natural criminal. The direct descendants of the feeble-minded woman first mentioned number twenty-nine, and in the past ten years twelve of these persons have spent an aggregate of twenty-two years in the poor asylum and orphans' home of the county. The total family members reported number forty-seven and extend over five generations.

One group of 13 feeble-minded families is recorded containing 68 individuals. Of these there were 18 in the first generation; 26 in the second; 24 in the third. With these degenerates it is not always true that when there is a little child there are three persons in a family. The paternity is not always known and in many cases we are compelled to count two persons, the mother and child. All the members of the first generation were feeble-minded; twenty of the second generation showed the same defect. The mental condition of the third generation is not given. The reason is that they were reported when they were at an age at which it could not be determined. Eleven of its members, however, are reported as illegitimate. The 11 women in the first generation were the mothers of 26 children. The 24 members of the third generation are the children of 12 of these. It will be noted that when the younger members of a generation are born in an institution, or become inmates very young, their mental condition cannot be reported and often is not known unless they are readmitted when

A RECORD OF THIRTEEN FAMILIES OF THREE GENERATIONS EACH.

	No. of persons.		Feeble-minded		Insane.		F. M. & Ep.		F. M. & Df.		Deaf & Dumb.		Unk. or normal.		Illegitimate.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
First generation.	7	11	6	9		1	1	1								
Second generation*	7	19	6	14						1		2	1	2		2
Third generation.	14	10											14	10	5	6

*No. of persons in 2d generation who had children = 12.

they become older and the psychosis can be determined. Neither the husbands nor the wives of the members of this group are counted in this table. Those enumerated are the direct descendants of the persons in the preceding generation.

It is not unusual to find in a poor asylum three generations of feeble-mindedness. Not long since, the speaker had grouped before him, at a poor asylum in the southern part of the State, four generations of feeble-minded persons—father born in 1817, daughter, granddaughter and great-grandson. There are nineteen members of this family; nine are feeble-minded and four are illegitimate. Most of them have been inmates of the institution where they were seen. Some of them recur to it from time to time yet. This is not a single instance, for in other poor asylums an equal number of generations, similarly afflicted, can be found, and in fact there are instances where five generations have at one time or another been inmates of such a county institution.

Years and years ago a single man here and there—a prophet in a strange land—began to call attention to the condition of the idiot. They were treated as animals in confinement. At the beginning of the present century the first institution was built for their care.

Dr. Walter E. Fernald tells us that the first recorded attempt to educate an idiot was made about the year 1800 by Itard, the celebrated physician-in-chief to the National Institution for the Deaf and Dumb at Paris, upon a boy found wild in a forest in the center of France, and known as the 'Savage of Aveyron.' This boy could not speak any human tongue, and was devoid of all understanding and knowledge. Believing him to be a savage, for five years Itard endeavored with great skill and perseverance to develop at the same time the intelligence of his pupil and the theories of the materialistic school of philosophy. Itard finally became convinced that this boy was an idiot, and abandoned the attempt to educate him. (Proc. Nat. Conf. Char. and Cor., 1893, page 203.)

In 1818 the American Asylum for the Deaf and Dumb, at Hartford, Conn., the first institution of its kind in this country, gave the first instruction offered in the United States to idiotic children. Following this several attempts were made in teaching such children in France, Switzerland and Germany. But a few could be cared for. Slowly the thought of the possibility of their improvement spread. The progress of the work was slow. Individuals were interested and pressed into it. Finally a state took some interest.

In 1846 the first effort was made for legal provision for the instruction of idiots in this country in New York. This was unsuccessful; but a few days later in the same year action looking to similar results was begun in Massachusetts. This culminated in legislation in 1848, providing for the education of 'ten indigent idiots.' Thus began our public institutions for idiotic or feeble-minded children. In New York efforts providing for such a school were repeatedly made, but it was not until 1851 that they were entirely successful and the act passed in that State. Pennsylvania was the third State to begin the work in 1852. It was followed by Ohio in 1857. One after another of our States has recognized the duty of providing education, training and care for these unfortunates. In a number of States institutions of the highest standing have been developed. Dr. Fernald tells us the early history of these pioneer State institutions in many respects was very similar. They were practically all begun as tentative experiments in the face of great public distrust and doubt as to the value of the results to be obtained.

At last it became recognized that those who had given years of study to the idiot

had a right to have an opinion and to express it. Then it came to be believed and advocated that in this class of defectives were many who were amenable to instruction if it were only of the right kind and taught in the right way. The children might be reached and helped.

First it was thought that many of these children could be educated to make their own way in the world. Finally it was decided that while many of them could be taught to be self-supporting under direction, but very few could ever leave the fostering care of the institution. Children they are and children they will be as long as they live. For, though they become old in years, mentally they will still be children.

More and more came the conviction that there should be custodial institutions. These were especially advocated for feeble-minded women under forty-five years of age. They would be safe and with no prospect of reproducing their kind. Now it has come to be regarded as the proper right and duty to retain control over these grown-up children during life. Some states have made a beginning for this purpose.

Never did we appreciate so strongly as we do to-day the untold misery and accumulating expense caused by the lack of control of our feeble-minded population. Their fecundity and animal instincts make them fit subjects for consideration, both on financial and moral grounds, to say nothing of the dangers that beset those of strong minds who have weaker bodies.

The problem presented to us is the manner in which these conditions shall be met. Its solution lies in an intelligent and general knowledge of the subject by the public, preventive measures by legal marriage restrictions and other means, the education of feeble-minded children and the custodial care of feeble-minded women.

AMOS W. BUTLER.

INDIANAPOLIS, IND.

SCIENTIFIC BOOKS.

Anatomy of the Cat. By JACOB REIGHARD, Professor of Zoology in the University of Michigan, and H. S. JENNINGS, Instructor in Zoology in the University of Michigan. 173 original figures by LOUISA BURRIDGE JENNINGS. Henry Holt & Co. 1901. 8vo. Pp. ix+498.

Teachers and students alike will welcome the appearance of this admirable text-book because it is practically the only work which treats of the entire macroscopic anatomy of the cat, the mammal most generally available for class-room study. Of the books on the cat hitherto published none unites in itself all the requirements of a satisfactory text-book; they are either inaccurate and diffuse or accurate and meager, while another class which covers parts of the subject exhaustively is not available because incomplete. We believe that, with the aid of this present work, a teacher will find no difficulty in conducting a thorough laboratory course and can cover the entire ground in a college year. The authors are to be congratulated, not only upon producing a book which will secure a higher grade of class-room work, but also upon the completion of an important scientific contribution which cannot fail to stimulate and encourage a wider teaching of elementary anatomy. In one sense this is not an elementary work; the descriptions are scientific and concise, without attempt at popular writing. Moreover, it presupposes a knowledge on the part of the student of such general matters as the nature of tissues, the functions of organs and the meanings of scientific terms. Hence its use would seem to call for accompanying lectures or for previous preparation in courses on histology and general biology.

We are glad to see that the authors have not cast the book in the form of a laboratory guide; structures are described in their proper order and relation, the amount of space devoted to the different systems of organs being determined not only by their relative importance, but also by the amount of work on each which can be expected from the average student. Thus, for example, almost one-half of the entire work is devoted to a description of the bones and muscles, and but one-eighth to the viscera.

The descriptive portion of the book is followed by an appendix of practical directions, covering forty-three pages. Herein are given general directions for study and for the preparation of material, together with special directions for the dissection of each group of organs—as they present themselves to the student and not in the order in which they are studied in the descriptive portion of the work. The separation of these notes from the body of the book of course preserves continuity to the descriptions and enhances the value of the book as a work of reference; on the other hand, it necessitates such an amount of turning of pages by the student that it would have been wiser to have brought the practical directions into closer relation with the text—at the beginning or at the end of each section or chapter.

In the matter of nomenclature, as the authors maintain, and properly, that the primary purpose of such a work is not to illustrate or defend any particular system of nomenclature, but to aid in obtaining a knowledge of the structures themselves, and as they hold that the time has not come for an absolutely uniform nomenclature, they have adopted such terms as they judge likely to be measurably permanent. As a basis, therefore, they use, as far as possible, the Latin terms (and their English equivalents) proposed by the German Anatomical Society, but freely substitute for these other terms, either when those proposed are not appropriate for the cat, as, for example, the names for the cerebral sulci or gyri, or when the substitutes are better known to English anatomists and are not likely to be given up, as, for example, *trapezoid* for *os multangulum minus*. In cases of substitution the Latin name proposed by the German Society is given as a synonym. Whenever a structure has two names, equally well-known, both names are given. It is certainly most desirable that each structure should have a single name; if however, there be two, the student should learn them.

As terms of direction the authors properly use, almost exclusively, such intrinsic terms as *dorsal* and *ventral*; *cranial* and *caudal*; *proximal* and *distal*; *medial* and *lateral*, and they discard the older extrinsic terms *anterior* and *posterior*; *superior* and *inferior*; *inner* and *outer*. *Dorsal* and *ventral* are also applied, less happily we think, to surfaces of the limbs; the dorsal side being indicated by the convexity of the joint, elbow or knee, the ventral side by the concavity of the joint. The constant use of adverbial forms such as *dorsad*, *craniad*, *proximad*, etc., certainly gives brevity and directness to the text; they do not add, however, to its elegance—nor does the use of *onto* for *on*.

We have examined the greater part of the book with care and find it to be well planned, clearly written and based on accurate original study. Some things are omitted which, from the general thoroughness of the work, one would have expected to find, as, for example, an account of the interesting arrangement of the tendons and ligaments attached to the terminal phalanges. To reduce the book to a convenient size, omissions, of course, are necessary; what shall be omitted must remain a matter of personal opinion. The drawings by Mrs. Jennings which illustrate the work are excellent; they show clearly what the student is expected to see and are not burdened with unnecessary detail. A few diagrams from frozen sections to show the relations of organs would have been instructive. The book is well made; type, paper, printing and binding are all good; and there is a capital index.

HORACE JAYNE.

Zell- und Protoplasmastudien. By F. DOFLEIN. 1900.

Under the above title Dr. F. Doflein publishes in brochure form a reprint of his paper in Spengel's 'Zoolog. Jahrbücher,' XIV. This contribution is the first Heft of the author's studies on the morphology and physiology of nuclear and cell-division. It deals, in the main, with the process of nuclear division in *Noctiluca miliaris*. The author gives a very detailed account of his work on preserved material. He differs in several particulars from the results of previous writers, the most important differences being his failure to identify the centrosome in any part of the astrophere, and his denial of a longitudinal splitting of the chromosomes as described by Calkins. The latter author has shown, from the arrangement of the chromatin threads at a certain phase in the division that

it is probable that a longitudinal splitting of the chromosomes takes place. Doflein does not find any evidence of such in process. In the absence of conclusive proof it is impossible to decide which of these two accounts is correct.

SCIENTIFIC JOURNALS AND ARTICLES.

The Plant World for August contains, besides short articles, notes and reviews, 'August Days,' by John Burroughs; 'Notes from Western Kentucky,' by Sallie F. Price, and, under the caption 'A Scanty Flora, a description of that of Bird Rock, Gulf of St. Lawrence,' by Henry E. Baum. But three species of plants are found on this islet: *Poa compressa*, *Achillea borealis* and *Plantago maritima*. Pauline Kaufman continues 'Orchids in Central Park,' and John Gifford describes 'The Dwarf Mistletoe, *Razoumofskya Prusilla*.' L. H. Pammel discusses 'Rare Plants and their Disappearance,' the drying up of sloughs and the overpasturing of the woodlot being accountable for the small numbers of the plants mentioned. In the supplement devoted to 'The Families of Flowering Plants,' Charles Louis Pollard describes the Trigoniaceæ and other families of the Geraniales and begins the description of the Sapindales.

The News Bulletin of the Zoological Society of New York appeared in new form with its last (July) issue, having been reduced to a small quarto about the size of SCIENCE. Besides a number of views of animals living in the park, there is a cut showing the state of the monkey house in June. The completion of a restaurant and of the Service Building is announced, and many improvements in the buildings and grounds are noted. Six species of mammals, twelve of birds and eight of reptiles were born in the park this present season. A special feature of the New York Zoo is its collection of reptiles, and the additions to this have been numerous during the first six months of the year.

The Osprey for July brings this periodical nearly down to date, and the August number is promised at an early day. The present issue contains besides shorter articles 'Camping on the Old Camp Grounds,' by Paul Bartsch; 'Stephen's Whip-poor-will,' by J. H. Riley; 'The Malar Stripe of Young Flickers and the Moult,' by William Palmer; 'The Blue Grosbeak in Eastern Kansas,' by Walter S. Colvin, and the sixth instalment of 'The Osprey or Fish-hawk; its Characteristics and Habits,' by Theodore Gill.

SCIENTIFIC journals are not often sold, and it is consequently a matter of interest that the market value of a special journal has been ascertained by the sale of the *Botanisches Centralblatt* to the International Association of Botanists. According to the *Compte Rendu* of the recent congress the price was 37,500 Marks, and the present editor, Dr. Uhlworm retains his position for five years, and if subsequently superseded receives an indemnity. About half the amount has been subscribed, and the balance has been advanced by the publisher, J. E. Brille, of Leipzig, who is to be paid 4 per cent. interest.

DISCUSSION AND CORRESPONDENCE.

DISCORD AND PSYCHOLOGY.

TO THE EDITOR OF SCIENCE: In the issue of SCIENCE for August 30 Mr. Max Meyer calls attention, in a discussion of 'Discords and Beats,' to a supposed error in my review of a recent book on physics, where I referred to Mayer's law expressing the duration of the residual auditory sensation as a function of vibration frequency. He is right in thinking it rare to find physicists well up with current psychological literature, a fact necessitated by the immense mass of literature now in all departments. This fact excuses Mr. Meyer for having apparently failed to read the investigations of Professor Mayer on this subject, which were published in the *American Journal of Science* (Oct., 1874, April, 1875, and Jan., 1894). This physicist did not assume that discord was necessarily due exclusively to beats. His own conclusions were tested in 1875 by a trained musician whose deliverances were given without considering anything else than the perception of discord. This was a purely psychological investigation, therefore, so far as musical sensation was concerned. If the psychologists have some time since agreed that discord cannot be defined by beats, this negative conclusion does not estab-

lish the proposition that all discord is wholly independent of beats. Whether it be due wholly or partly to beats or to something else quite unknown as yet, Mayer's curve is sufficient to disprove the statement that the maximum of discord is due to always the same number of beats, whatever may be the pitch.

It was not my intention to publish any detailed criticism of the point to which I took exception in my review of the book of physics under examination. But Mr. Meyer will probably agree with me in objecting to the following sentences, which may now be quoted: "One cause of discord is the presence of beats between the two notes, and the greatest discord results when the beats are about 32 per second. If the number of beats is fewer than 10 per second, they are not agreeable, but do not produce discord. Discord is caused by sounding together notes that give more than 10 and less than 70 beats per second." Whatever may be the cause of discord now agreed upon among psychologists, Mayer's law comes nearer to being a statement of the truth than the sentences just quoted. The author is creditably cautious in assigning the presence of beats as 'one cause.' Presumably it may not be the only cause. But his quantitative statements warranted my criticism that he had "defined 'discord' more sharply than the facts warrant by failure to recognize Mayer's law."

If Mr. Meyer will criticise the quoted sentences from the standpoint of the psychologist he will doubtless confer a favor upon physicists who have not kept up with recent advances in psychology.

W. Le Conte Stevens.
Washington and Lee University,
August 31, 1901.

MAGAZINE ENTOMOLOGY.

It has been the habit to charge newspapers with the dissemination of scientific misinformation, and undoubtedly with considerable justice. But they are not the sole sinners. In the September number of *McClure's Magazine* there is a paper entitled 'Next to the Ground; Stories and Scenes of Farm Life,' by Martha McCulloch Williams. The amount of misinformation it conveys cannot be equalled by any bit of newspaper writing, and for ignorance on the part of the author it is certainly entitled to the palm. First, we have information about the dragon fly, and the superstition concerning snakes that is connected with it; that is all right; but we are immediately afterward informed that it begins its early life as a fat white grub, variously known as Hellgrammite, dobson, etc. Now, in the first place, the hellgrammite is neither white, nor fat, nor is it a grub; and in the second place, it has absolutely no connection with the dragon fly.

From any elementary work on entomology, national or foreign, the writer could have obtained an accurate life history of the dragon fly, and also information as to the adult stages of the hellgrammite. She may have seen a dragon fly; she certainly never saw a hellgrammite to know it. Then we learn something about the locusts, and most interesting, we are told that the eggs are laid in the pith of dying twigs. So much has been written about these insects that it does seem as if the authoress might have known better than to make an assertion of this kind. Pithy stems are rarely used by locusts, if at all, and dying twigs are never attacked. The eggs are always laid in growing shoots, and in the wood itself. I wonder where she saw the black beetles or 'Betty bugs' that were three inches long? She speaks of them as 'Scarabs,' and the largest of these, occurring in the United States entitled to that name, are not more than one inch in length.

More marvelous than anything else is the description of the change from the tumble bug, black and loutish, into a 'June bug,' green all over, with copper yellow tints on the legs, etc. Where in the world this information came from, if it was not the product of overstrained imagination, seems incomprehensible. In fact, reading the entire paper, which covers eight pages, there is more dense ignorance and absolute misinformation crowded into it than I have seen anywhere on a similar subject within the last decade. And what there was in it anywhere, to recommend to the editor its publication, seems almost beyond finding out. There has been of late years a great revival of interest in natural history. We have had many useful and accurate books, including the topics on which Martha

McCulloch Williams writes. It would seem as if anyone intending to publish concerning natural history would at least familiarize himself or herself with the subject. It is discouraging to find a magazine like *McClure's* accepting and printing an article of this character.

JOHN B. SMITH.

NEW BRUNWSICK, September 12, 1901.

CURRENT NOTES ON PHYSIOGRAPHY.

THE RANGES OF THE GREAT BASIN.

THE mountain ranges of the Great basin in Utah and Nevada have been explained, chiefly by Gilbert and Russell, as due to block faulting, but without sufficient statement concerning the form of the region before faulting or of the amount of erosion since faulting. Hence the ranges have sometimes been imagined as presenting long, gentle back slopes where the pre-faulting surface has been tilted up, and abrupt frontal cliffs where the fault scarp is revealed; and in the absence of statement to the contrary it has been sometimes supposed that the faults by which the blocks are limited were determined by ordinary stratigraphic evidence.

Spurr now offers a new interpretation of these ranges ('Origin and Structure of the Basin Ranges,' *Bull. Geol. Soc. Amer.*, XII., 1901, 217–270, pl. 20–25). Finding monoclinal structure not persistent, finding much dissection on both slopes of the ranges, and finding no stratigraphic evidence of faulting along the base of the ranges, he discards the theory of block faulting and explains the mountains as residuals of a disordered and greatly denuded mass, the intermont depressions being regarded as valleys of erosion produced under a former greater rainfall and now clogged with waste since a drier climate has set in.

Attention is here called to the different values given by Spurr to the stratigraphic evidence of faults where both members of the faulted series are seen, and to the physiographic evidence where only one member is visible. Faults determined by ordinary stratigraphic evidence are spoken of as 'actually observed' (266), while faults announced by previous observers on physiographic evidence are altogether rejected, apparently because they are not confirmed by stratigraphic proof. As a matter of fact, no faults (meaning thereby surfaces of fracture on which movements of dislocation have taken place) have been actually observed as such in the Great basin; faulting is there as elsewhere a matter of inference. In the case of faults proved by stratigraphy, the termination of one series of strata against another may be more or less closely observed; and then instead of believing that both sets of strata were 'made so' in the beginning, it is reasonably inferred that they both originally had greater extension, that they were brought into their present relations by dislocation, and that the dislocated mass has been carved into its present form by greater or less erosion. This demonstration is commonly accepted as so compulsory and all other explanations seem so infinitely improbable, that faulting proved by stratigraphic evidence is often treated as if it were a matter of first-hand observation, and given an equal order of verity with the plain facts of strike and dip.

In the case of faults proved by physiographic evidence, the outcrops of a series of strata in an escarpment or on a mountain side are directly observed; and then instead of believing that they were made so, it is inferred that the invisible parts of the series have been in some way removed. On finding that their removal cannot be reasonably accounted for by erosion alone, the aid of faulting is invoked, a greater or less amount of erosion being supposed to precede and to follow. This argument of course involves such a knowledge of the observable facts of structure and form, and such an understanding of the processes of erosion and of the forms resulting therefrom, that, while certain forms (such as the Appalachian ridges of Pennsylvania) may be reasonably ascribed to erosion alone acting on a deformed structure, certain other forms (such as the Basin ranges) may as reasonably be held to be beyond production by erosion, without relatively recent faulting. This demonstration of faulting may be just as logical as that based on stratigraphy alone, but it is somewhat more complicated and it is much less commonly employed.

Now inasmuch as the block faulting of the Basin ranges has been determined in nearly every case by the physiographic method alone,

it is certainly desirable that discussions of the Basin range structure should include a consideration of the criteria for the demonstration of faults by this means, when only one member of the faulted series is visible. Yet no such consideration of the problem is given by Spurr. He confirms earlier work by finding that marginal faults are not to be determined along the base of the ranges (except in rare instances) by ordinary stratigraphic evidence. He reiterates the undisputed fact that great erosion has occurred since the ancient folding and faulting within the body of the ranges, and he illogically infers from this that recent faulting, marginal to the ranges, has not taken place. Instead of dealing with the problem at issue—the sufficiency of physiographic evidence to prove block faulting—he asserts without adequate discussion the sufficiency of erosion to produce existing forms, and after the briefest consideration he denies the peculiar faulting that has been reasonably inferred on physiographic grounds to be essential for the production of the ranges. This is very much as if one should deny the modern uplift of the Appalachian Piedmont district after its broad denudation, because no strata containing marine fossils lie upon it to attest its elevation. The block faulting of the Basin ranges may perhaps be some day disproved, but not until the evidence of faulting accepted by Gilbert and Russell has been shown to be valueless.

PHYSIOGRAPHIC EVIDENCE OF FAULTING.

The essential elements in the physiographic evidence of faulting in the Great basin are the impossibility of accounting for the presence of the mountain ranges if the intermont depressions have been produced by erosion alone, and the ease of accounting for them if the rough form of the region has been blocked out by faulting, leaving erosive processes only the smaller work of trimming the mountains into their present shape. The difficulty of dispensing with faulting is both qualitative and quantitative. In the first place, the structure of the ranges is commonly oblique to their border, so that the faulted margin passes indifferently from one structure to another, as in the accompanying figure; if the ranges were the residuals of a long period of undisturbed erosion, such a lack of correlation between border and structure would not be looked for; but if the ranges are limited by faults at one side or both, the

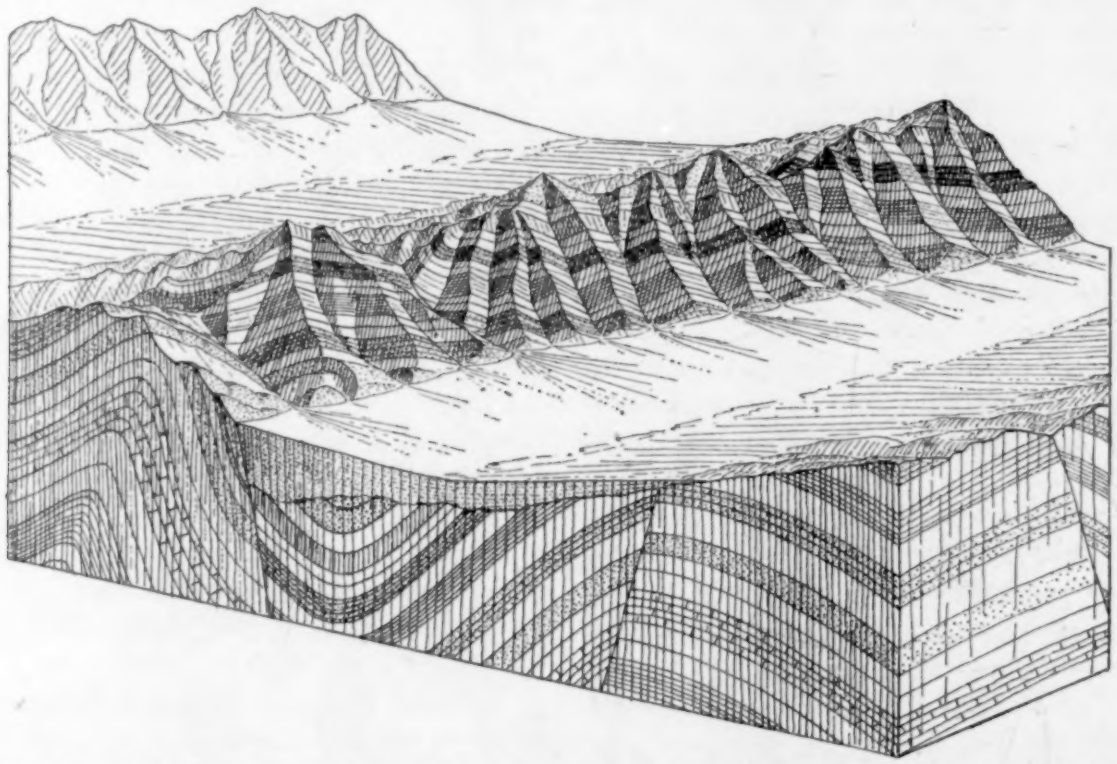

FIG. 1. Diagram of a mountain carved on a faulted block of previously deformed and denuded strata.

indifference of border to structure is natural enough. In the second place, the body of each range is usually continuous, although it may be incised by sharp-cut valleys; if the ranges were the residuals of a period of undisturbed erosion long enough to have permitted the excavation of broad intermont valley-lowlands, each range should be divided into isolated mountain groups by the opening of wide branch-valleys in its mass; but if the depressions and the ranges are blocked out by recent faulting, the continuity of the ranges is to be expected.

Both these tests are best met in southern Oregon, where the ranges as described by Russell are very little affected by erosion after faulting. Neither test is well met by certain ranges in southeastern California described by Fairbanks as almost worn down to grade. In Utah and Nevada both tests are well borne; but no definite statement has yet been published concerning the amount of erosion that has taken place in this district since the block faulting; nor has any careful inference been made as to the form that the region had before faulting, some remnants of which may perhaps still be detected on the lower back slope of the ranges. The absence of steep scarps along the faulted border of a range does not bear closely on the problem, although Spurr attaches much importance to it. Recent and rapid faulting would produce a scarp; but similar scarps produced less recently would now be more or less completely dissected and destroyed. Gradual faulting, even if continued into the historic period, would produce only a low basal scarp; the upper part of the fault face would be battered back and ravined. The truncated ends of certain spurs of the Wahsatch range near Prevo, Utah, seem to result from faulting of this kind, the fresh scarp that follows the base of the range being the product of the most recent episode of faulting.

No features due to recent faulting are seen in the Appalachians. The ridges there are intimately dependent upon the harder strata, the base of a ridge always follows the strike of the individual ridgemaker, and the lowlands between the ridges are demonstrably excavated by erosion on weak rocks. All these are conditions which no one has shown to obtain in the Great basin; yet Spurr says: "Suppose the Appalachians, which likewise consist of parallel ridges eroded along lines of folding, should become arid, so that the rivers were unable to remove the detritus and the valleys become choked. There would develop in the course of time exactly what exists in the Basin region, namely, a nearly level desert, containing a series of parallel, synclinal, and anticlinal ranges" (p. 255). The strongest dissent from this unwarrantable comparison must be expressed.

THE KENTUCKY MOUNTAINEERS.

AN article that might serve as the type of many more is a description of the Kentucky mountaineers by Ellen C. Semple ('The Anglo-Saxons of the Kentucky Mountains: a Study in Anthropogeography,' *Geogr. Journ.*, XVII., 1901, 588–623). The dissected Alleghany plateau, which is of mountainous ruggedness in Kentucky and West Virginia, shares with the mountains of North Carolina the unenviable distinction of being less affected by civilization than any equal area east of the Rockies. So many old customs are there preserved that the people have been well named 'our contemporary ancestors.' Miss Semple's account of these primitive Americans is based on personal observation and affords many excellent illustrations of the consequences of living in a region too rough for easy movement and too poor to attract immigrants.

W. M. DAVIS.

THE UNIVERSITY OF CHICAGO'S FIELD WORK IN BOTANY, GEOLOGY AND ZOOLOGY.

PRESIDENT HARPER, of the University of Chicago, in his last quarterly statement gives the following details in regard to field work:

The work in biology at the Marine Biological Station at Wood's Holl, Mass., is largely in charge of University of Chicago men, the director and the majority of the staff being from this institution. The director of the Laboratory of the Brooklyn Institute at Cold Spring Harbor, Long Island, and one of the botanical staff this summer were members of this faculty. The work at both these

laboratories may be looked upon as field work of a somewhat permanent type. The courses are credited at the University of Chicago, although not formally under its charge.

Besides the local field work in connection with residence courses in botany, zoology and geology, field work during the past summer has been conducted at a distance from the University by the departments of geology and botany.

I. GEOLOGY.

1. A course in elementary field geology was given by Mr. R. D. George for four weeks of the second term of the summer quarter, the remainder of the term being devoted to the preparation of a report on the field work. A party of eleven traversed a region in the Mississippi valley between Prairie du Chien, Wis., and Muscatine, Ia. They devoted themselves to a study of (*a*) Paleozoic strata and fossils, (*b*) the topographic features of the driftless area in Iowa and Wisconsin, (*c*) the stratified drift of the valleys, (*d*) the loess, and (*e*) the lead and zinc deposits of the Dubuque region.

2. Professor R. D. Salisbury is in charge of several parties in Montana, Idaho and Utah. These parties consist of advanced students and are working somewhat independently, Professor Salisbury visiting the different parties at intervals and making suggestions regarding the work. A party of two is at Kipp, Mont., a second party of two at Kalispell, Mont. These two parties are investigating the phenomena of local glaciation in the Rocky mountains. Another party of two is at work in the Santa Fé mountains of New Mexico, studying their structural and stratigraphic features. A party of six, under the immediate direction of Mr. W. W. Atwood, is at work on the Wahsatch mountains, studying similar problems.

BOTANY.

1. A party of eight, under the direction of Mr. S. M. Coulter, of Washington University, spent the first part of the second term of the summer quarter at North Manitou Island, passing over later to the mainland in the vicinity of Petoskey and Charlevoix, studying the ecological relations of the flora in these regions. This work is essentially an examination of the way in which plants associate themselves and an investigation of the determining factors of environment for each society.

2. Similar but more extended work has been undertaken by a party of eighteen in charge of Dr. H. C. Cowles. This party has a car on the Great Northern Railroad, and is stopping at various favorable localities through Montana and Washington. Two weeks were spent at Flat Head Lake, Montana, the site of the biological station of the University of Montana, whose facilities were put at the disposal of the party; another week was spent at Belton, Mont.; and other stops were made at Leavenworth and Seattle, Wash. This is the most extended field trip yet offered in the department of botany and has certainly presented unusual advantages to the students for a study of widely different floras under most varied climatic conditions.

NEW YORK BOTANICAL GARDEN.

The Misses Olivia E. Phelps Stokes and Caroline Phelps Stokes have recently contributed the sum of $3,200 to the Garden, of which $200 is to be added to the Special Book Fund, the remainder is to constitute a fund, the income of which is to be devoted to the protection and preservation of native wild flowers. This will increase the effectiveness of the Garden in a very desirable direction, and enable it to do much in the promotion of a healthy public sentiment in the matter.

Dr. M. A. Howe, assistant curator, accompanied by Mr. William Lange, museum aid, and Mr. Clifton D. Howe, of the University of Chicago, made an exploration of Nova Scotia. Special attention was paid to the collection of marine algæ, of which several thousand specimens, preserved in fluid and dried condition were secured. About 8,000 sheets of herbarium specimens of land plants were secured. The exploration reached New York on September 9. The expenses of the expedition were chiefly defrayed from funds contributed by Mr. George W. Perkins, of the Board of Managers.

Dr. D. T. MacDougal, first assistant, spent a portion of the summer in Montana in cooperation with the biological expedition of the State University. Dr. MacDougal was accom-

panied by Mr. Wilson P. Harris, as voluntary assistant, and secured a large number of plants for the outdoor plantations, many kinds of seed for growing additional species and over 900 numbers of herbarium and museum specimens, collectively including more than 3,000 specimens. In addition to these, all the duplicates of the collections of the University of Montana were obtained. Attention was also given to climatological observations. Mr. Harris devoted his attention chiefly to lichens. The exploration extended along the Mission range of mountains and into the southern Kootenais, and regions were reached which had never been touched by such an expedition. The expenses of this work were paid from funds contributed by Mr. W. E. Dodge, of the Board of Managers.

Dr. MacDougal is acting director-in-chief during the absence of Dr. Britton.

Professor L. M. Underwood, of the scientific directors, recently returned from a tour of Porto Rico, bringing with him a nice collection of cacti from the arid southern part of the island, some 75 species of seeds, many of which have already germinated in the propagating houses, a number of museum specimens and about 1,000 specimens for the herbarium. He will spend a month now in the Rocky Mountains of Colorado, continuing the exploration begun by Dr. P. A. Rydberg. A recent gift from Mr. Adrian Iselin has made the extension of the important work possible.

Professor N. L. Britton, director-in-chief, left for St. Kitts, and other of the Windward Islands, on August 30, accompanied by Mr. John H. Cowell, director of the Buffalo Botanic Gardens. The object of their expedition is to obtain living tropical plants and seeds for the conservatory collections, specimens for the public museums, and as complete a collection of herbarium specimens of these islands as can be obtained during a month or six weeks' residence there. This work is in continuation of the botanical exploration of the West Indies and Central America instituted in 1899, when Mr. A. A. Heller and Mr. Samuel Henshaw were sent to Porto Rico by means of funds contributed by Mr. Cornelius Vanderbilt, and of Professor Underwood's recent work in Porto Rico made possible by funds contributed by Mr. W. E. Dodge.

Mr. Percy Wilson, museum aid, who was sent to the East Indies in March, accompanying Professor Todd, of Amherst College, on the total eclipse of the sun expedition, has returned, bringing with him ten large cases of museum specimens illustrating economic products, a number of living orchids, a collection of seeds for growing in the propagating houses, and a valuable set of books and pamphlets treating of the botany and agriculture of that region. He visited the botanical gardens at Singapore and at Buitenzorg, Java, where he was most kindly received, and arranged with these institutions for important exchanges of plants, books and specimens.

SCIENTIFIC NOTES AND NEWS.

THE French Institute will make the first award of the Osiris prize in 1903. It is of the value of 100,000 francs, and is awarded to the one who in the preceding three years accomplishes the most important work for science, industry or literature.

THE city of Berlin will contribute $25,000 toward the Virchow foundation for research, now being enlarged in honor of Professor Virchow's eightieth birthday.

THE Austrian Emperor has addressed an appreciative autograph letter to Professor Ed. Suess, the eminent geologist, on the occasion of his retirement from the University at Vienna.

As the newspapers fully report, the steamship *Erik* reached North Sydney, Cape Breton, on August 14, with news from Lieutenant Peary. During the eighteen months in which no news had been received from him, he had succeeded in rounding the northern limit of the Greenland Archipelago, and in reaching the highest latitude gained by an American, 83° 50″ north. Lieutenant Peary remains at Payer Harbor, and will attempt to reach the most northerly point possible in the spring of next year. Messrs. Stein and Warmbath are returning on the *Windward*, but no news is brought of Captain Sverdrup on the *Fram*.

MEMBERS of the British Geological Association visited France last month. They were

met at Clermont by MM. Glangeaud and Giraud, and after visiting the department of Puy de Dôme explored Le Cantal under the guidance of M. Boule.

Dr. A. W. Nieuwenhuis has returned from a two years' expedition across the unexplored regions of Borneo, made under the auspices of the Dutch government. Dr. Nieuwenhuis's previous expeditions to Borneo have yielded results of much zoological, geographical and ethnographic interest.

Dr. H. F. Knowlton, of the U. S. Geological Survey, has just returned from a trip, made in company with Dr. John C. Merriam, of the University of California, through the John Day Basin, Oregon. The special object of the investigation was to secure collections of fossil plants from the rich beds of the region, and also of the vertebrate fauna of the recently differentiated rattlesnake beds. Much valuable material was secured.

Dr. George A. Dorsey, curator of the department of anthropology at the Field Columbian Museum, Chicago, has returned from a trip among the Hopi Indians of Arizona.

Professor F. W. Putnam, professor of American archeology and ethnology in Harvard University, is at present in California, where, as last summer, he is looking into the case of the Cavalaras skull.

Dr. E. W. Allen, of the Office of Experiment Stations, Department of Agriculture, has recently returned from an extended tour of the agricultural experiment stations in the Northwest and Alaska. He finds that the Alaska stations are meeting with encouraging success in demonstrating the entire feasibility of growing the vegetables necessary to supply the needs of the local population, and in maturing the cereal grains. He will recommend the taking up of experiments in raising and feeding farm animals to determine the extent to which this is practicable with Alaska-grown products.

Reports received from Professor C. C. Georgeson, the officer in charge of the Alaska experiment stations, who has just returned from a trip to the interior and down the Yukon, are exceedingl encouraging. New potatoes, cabbage, cauliflower and other vegetables were ready for the table early in August, and gardens planted with a variety of annual flowers were in full bloom. Rye and barley were ripened this year at the station at Rampart on the Yukon, with a fair prospect for oats and wheat. Extensive tracts of land were found on the lower Yukon which were covered with a luxuriant growth of grasses, often six feet in height, and apparently well suited to agriculture.

Professor John B. Smith, of Rutgers College, is devoting a good portion of the present season to the study of the mosquito question in New Jersey. The occurrence of these insects in great swarms along the coast, lessens the value of shore property by many millions of dollars, and some localities farther inland are rendered almost uninhabitable. The object of the present inquiry is chiefly to establish the distribution of the various species that occur in the state, their relative abundance and the general character of the breeding places. It is intended to make the facts so ascertained the basis of the report to go to the Legislature, which will probably be asked to make a substantial appropriation to carry on the work in a more thorough and comprehensive manner. It seems probable that by cooperation of the state and municipal authorities, aided by individual effort in some cases, the pest can be very materially reduced. It will require, however, a very careful study of the problem before a comprehensive plan of campaign can be formulated.

Mr. William Campbell, B.Sc., F.G.S., a graduate of and former instructor in metallurgy and geology in Durham College of Science, England, has been honored for the third time by the award of an 1851 Exhibition Research Scholarship. For the past two years Mr. Campbell has been engaged in researches upon the constitution of alloys, working in the laboratories of Sir William Roberts-Austen, at the Royal School of Mines (London University), and at the Royal Mint. Mr. Campbell, at the request of the commissioners by whom the award is made, proposes to continue his researches at Columbia University in Professor Henry M. Howe's laboratory.

IN view of the resignation of Dr. Thomas L. Watson, assistant geologist of the Survey of Georgia, to accept a chair at Denison University, the State Geologist, Dr. W. S. Yeates, Atlanta, will be glad to enter into correspondence with geologists seeking such a position.

DR. EIJIAOYAGI, of the University of Kioto, is at present in the United States investigating methods for the application of electricity.

PROFESSOR A. C. HADDON, of Cambridge University, is to visit the United States, reaching New York on the steamship *Campania* of the Cunard Line about September 28 and remaining in this city until about October 7. While in this country he will deliver lectures, illustrated by excellent stereopticon views, at various educational institutions upon some of the following subjects:

The House and Family Life of the Natives of Sarawak.
Ceremonial and Secular Dances of the Papuans.
A Trip into the Interior of Borneo.
The Papuans.
Evolution in Art.
The Descriptive Art of Primitive Peoples.
The Life of a Torres Straits Islander.

As is well known, Professor Haddon is an authority on 'The Evolution of Art' and kindred subjects. He has worked for many years among the tribes of New Guinea, Borneo, Torres Straits and the adjacent territory, conducting the recent Cambridge expedition to that region.

MR. WALDRON SHAPLEIGH, a well-known industrial chemist of Philadelphia, died in Maine on August 30. He was born in Philadelphia in 1848, and was assistant professor of chemistry at Lehigh University from 1868 to 1872. He then studied abroad, and was connected first with the King's County Sugar Refinery and later with the Welsbach Company. He was an authority on the rare earths.

DR. CHARLES MELDRUM, F.R.S., formerly director of the observatory in Mauritius, died on August 28, at the age of eighty years.

THE Rev. Moses Harvey died at St. Johns, Newfoundland, on September 3, at the age of eighty-two years. He retired from active work in the Presbyterian church in 1878, and has since been engaged in literary and scientific work.

THE death is also announced of Professor Alwin von Coler, surgeon-general of the Prussian medical service, at the age of seventy years.

THE German Geological Society will hold its forty-sixth meeting at Halle during the first week in October.

THE astronomical instruments 'conveyed' by the German soldiers from the Pekin Observatory have reached Germany, and it is said will be placed in the park of Sans Souci. Many of the German newspapers protest against the detention of these instruments.

THE director of the Paris Jardin des Plantes, M. Perrier, has asked the French government for the sum of $2,000,000, which he claims is required for the buildings and collections.

A MAGNETIC observatory is being constructed by the government at Sitka, Alaska, under the direction of Dr. H. W. M. Edmonds, of the U. S. Coast and Geodetic Survey.

AN interesting and useful pamphlet, says *Nature*, has recently been issued by Mr. A. Hilger, containing full description and details of manipulation of the Michelson Echelon grating. Many of the principal universities of Europe have been provided with this very powerful means of spectroscopic determination, and the experience gained has been sufficient to permit the designing of a standard type of instrument. In this the thickness of each plate is 10 mm., and the width of each step 1 mm. The progressive precision in the working of the plates has enabled Mr. Hilger to avoid the considerable loss of light which was caused in the original instruments by the plates not being mechanically clamped together. They are now held in position by a screwed frame, which can be so adjusted that no distortion is perceptible, while the increase in brilliancy of the spectra is very noticeable.

MAJOR RONALD ROSS, Royal Army Medical Corps, landed at Plymouth on September 2 on his return from West Africa. He gave a press

representative an account of the work which is being done in Freetown and Lagos under his direction as leader of the expedition sent out by the Liverpool School of Tropical Medicine, in the course of which he said it was too early to speak of the sanitary work at Freetown, but the number of the mosquitoes in the center of the town had certainly been largely reduced. There were hardly any to be found in Dr. Logan Taylor's house, where formerly they used to swarm, and the same state of affairs prevailed at Government House, where Major Ross stayed with the Governor. Dr. McKendrick, of the Indian Medical Service, who had been deputed to watch over the operations of the expedition on behalf of the Government of India, was not bitten once during a whole month. In former days he would certainly have been bitten at least five or six times a day. Major Ross said he had no doubt that the expeditions would be successful and that they would be continued as long as necessary. At Lagos the measures adopted by Sir William Macgregor were admirable and he was confident of success. The Governor of Accra, Major Nathan, was anxious to start similar work there at once, and doubtless experts would be sent out immediately by the Liverpool School of Tropical Medicine. On the whole, Major Ross expressed himself as being well satisfied with his tour. Personally he did not think the health of the Coast was as bad as was painted. He believed that by minute attention to details the place would be made as healthy as India for Europeans. Old West Africans are sober and careful and generally live in very good health. It was the improvident newcomer who generally seemed to suffer. He had been informed that there was a high rate of mortality amongst such on the Cape Coast.

UNIVERSITY AND EDUCATIONAL NEWS.

Mrs. Phoebe Hearst has agreed to pay all the expenses of a department of anthropology at the University of California, which will be devoted especially to the study of Indians of the Pacific coast.

Mr. Aaron French, the Pittsburg manufacturer, who has made large gifts to the Georgia School of Technology, has established a third scholarship in that institution.

Syracuse University receives about $40,000 by the will of the late Justice George N. Kennedy.

By the death of Mrs. Henrietta Cramp, Wesleyan College, at Bloomington, Ill., has received $50,000, bequeathed to it by the late Rev. Samuel Cramp.

We recently had occasion to call attention to the great development of the universities of the Central and Western States during the past ten years. There is every reason to suppose that in the course of the next ten years a great advance will be made in the Southern States. Tulane University has recently made great progress, and the University of South Carolina, under the presidency of Dr. F. P. Venable, will have this year about 600 students. This university should be included among those competent to carry on advanced work, though it was omitted from our summary of the universities awarding the degree of Doctor of Philosophy. There were, as a matter of fact, two doctorates of philosophy awarded last year, as follows:

Archibald Henderson, Mathematics: 'The Cone of the Normals and an Allied Cone for Central Surfaces of the Second Degree.'

James E. Mills, Chemistry: 'Some Molecular Changes caused by Rise in Temperature.'

As a result of the recent troubles in the Storrs Agricultural College, Mr. George W. Flint has been dismissed from the presidency. Professor R. W. Stimson, who holds the chair of English at the College, has been appointed acting president.

Professor E. M. Wood, of Baker University, at Baldwin, Kansas, is to succeed the late Professor Henry Benner, as professor of mathematics and astronomy in Albion (Mich.) College.

Professor Thomas C. Esty, of Amherst, has succeeded Professor Baker in the chair of mathematics at the University of Rochester.

Paul Arnold, M.A., of Los Angeles, has been appointed professor of mathematics in the University of Southern California.